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AUTONOMIC CORRELATES OF LEVELS OF PROCESSING IN MEMORY

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled "Autonomic Correlates of Levels of Processing in Memory," submitted by Lennard Michael Shangi in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

ABSTRACT

Craik and Lockhart (1972) proposed a levels of processing approach to human memory. The basic notion of this proposal is that retention performance is a positive function of depth of processing. A problem of circularity emerges in any attempt to index depth of processing by retention performance. Thus, the definition of depth of processing remains a problem.

The present study examined two major questions, (i) whether autonomic responses could index the three qualitatively distinct levels of processing in memory postulated by Craik and Lockhart, and (ii) whether autonomic responses could reflect the differential psychological processes which underlie incidental vs intentional learning.

There were two learning conditions (incidental/intentional) with three levels of processing (physical, phonemic, and semantic) in each. Changes in heart rate (HR) and GSR along with recall performance and reaction time of 46 male undergraduates were studied. Each trial consisted of the presentation of an orienting question and an imperative word-stimulus separated by a 6-second interval. Before the word was exposed subjects were asked a question about it. The purpose of the question was to induce the subject to process the word to one of three target levels. For example, shallow processing

was encouraged by questions about the word's typescript; an intermediate level of processing was induced by questions about the word's sound characteristics; and a deep level of processing was encouraged by questions about the word's meaning. Changes in HR and GSR were recorded concurrent with the task. Subjects in the incidental condition were given unexpected recall, while subjects in the intentional condition were given an expected recall test at the end of the encoding trials.

The performance results showed that intentional recall was superior to incidental recall, but there was no difference in reaction time between these two learning conditions. In general, deeper levels of processing in both learning conditions were associated with longer response latencies and higher recall performance. Also, there was greater differentiation between levels of processing in terms of recall in the incidental than in the intentional condition.

The autonomic results showed that measures of HR change, but not GSR directly differentiated between learning conditions with the intentional condition showing lower HR. Within-Ss analyses of HR changes showed that fore-period acceleration distinguished between levels of processing in the incidental but not in the intentional condition. GSR magnitude and frequency associated with the orienting question differentiated between levels of processing in the incidental, but not in the intentional condition. GSR recovery to the imperative stimulus (averaged over learning conditions) was the only GSR measure associated with the imperative stimulus to

differentiate between levels of processing.

In general, the behavioral results replicate that of Craik and Tulving (1975), and support their levels of processing model of memory. It is suggested that psychophysiological indices are a potentially useful supplement of behavioral measures, and that they enhance the logical and empirical status of such psychological concepts as 'levels of processing', thus increasing our understanding of the nature of learning processes.

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CHAPTER I

INTRODUCTION

For more than a decade, models of human memory have been generally concerned with the structural aspects of the memory system. More specifically, these models have been dominated by the structure of their inherent stores and the mechanisms of transfer of information between them. In recent years however, (Craik and Lockhart, 1972; Craik and Tulving, 1975; Craik and Jacoby, 1975; and Craik, 1973) a relatively new theoretical framework in memory has emerged. This model may be described as a process approach to learning and remembering, as opposed to its predecessors - the temporally structured multistore models which were concerned primarily with interstore information transfer. The new model is called the levels of processing model, and it prpposes that recall and recognition is a function of depth of encoding.

The model, although a recent and almost deceptively simple formulation, has dramatically changed the attitudes of some theorists concerning the operation of the memory system. Despite its recency, already the model has begun to demonstrate its fruitfulness in generating research and new insights into learning and remembering. However, despite its potential utility and its lack of widespread criticism, the model is not without its problems. The most obvious

deficiency associated with the model is the lack of sufficiently adequate definition of "depth" of perceptual analysis. A number of authors have acknowledged this difficulty and have suggested a number of ways to describe depth. For example, Bower (1975) and Herriot (1974) suggested that depth be indexed in quantitative and qualitative terms by the number and type of attributes analysed. Bower and Carlin, (1975) similarly proposed that the amount of detail attended to may serve to define depth. Although these definitions seem reasonable, they have not been empirically reinforced. Using degree of retention as an index of depth, has obvious dangers of circularity and must be rejected. Craik and Tulving, (1975) support with qualification the use of processing time as an independent index of "depth". In a recent study (Lawson, 1976), the problem of an inadequate definition of depth has again emerged.

Another important unresolved issue related to the levels of processing model is its inadequacy in distinguishing between incidental and intentional learning. In regard to this problem, Craik and Tulving, (1975) adopting the arguments of Postman (1956 and 1964), minimizes the incidental-intentional distinction, despite evidence to the contrary.

In the search for an independent measure which may help to distinguish between "shallow" and "deep" processing, and between incidental and intentional learning, psychophysiological measures seem to be likely candidates. Several investigators have reported consistent relationships between autonomic response patterns on the

one hand, and attention, effort, and information processing on the other. The above proposition for indexing depth of perceptual analysis, seems plausible if one adopts Triesman's (1969) model of attention and information processing as a working assumption. According to this model, sensory analyses are carried out relatively easily and require very little attention. Whereas, deeper cognitive analyses progressively require more attention for successful completion. The rationale for this proposition may be further enhanced by Craik's and Jacoby's (1975) claim that "The processes of attention are seen as regulating the analyses performed on the input-processing will be apparently 'preattentive' or 'automatic' when little processing is required .... The more complex and unfamiliar the processing, the more attention must be devoted to the process of analysis." (p. 3).

Continuing in this vein of argument, several recent studies (Bernstein, 1969 and 1975; Tursky, Schwartz, and Crider, 1970; Coles, 1974; Coles and Duncan-Johnson, 1976; and Lacey, 1967 and 1970), have supported the notion that autonomic response patterns may provide reliable indices of the amount of attention involved at different levels of perceptual analyses of stimuli. Further, Pribram (1975) and Vinogradova (1970) have demonstrated that there exists an intimate interaction process between the central information processing system, the central arousal system, and peripheral autonomic reactivity during stimulus encoding.

Pribram (1975) proposed three distinct, but interacting neurophysiological systems which influence information processing.

These systems are; the amygdala which mediates arousal, the basal ganglia which mediates activation or readiness, and the hippocampus which mediates effort. According to Pribram: "Clearly, in the intact organism, these control systems interact with each other as well as with the information processing system where the representational mechanisms become constituted." (p. 133). Vinogradova (1970) has documented the role of the hippocampus as either blocking or de-blocking the reticular activating system as appropriate, during information processing. In addition, the clinical evidence linking the hippocampus to memory consolidation and storage is abundant (eg., Milner, 1959, 1960, and 1968; Vinogradova, 1970; and Luria, 1973).

The link between the three attentional systems proposed by Pribram (1975) and the peripheral autonomic system is also well documented. Several investigators (eg., Bagshaw and Benzies, 1968; Pribram, Reitz, McNeil, and Spevak, 1974) reported that the phasic electrodermal response terminates more rapidly in hippocampectomized monkeys than in normal controls. Pribram (1975) reported that in hippocampectomized monkeys, GSR reequilibrated more rapidly than in normal controls. He interpreted this as indicating that slower GSR recovery meant more prolonged processing. With regard to heart rate, Bagshaw and Benzies (1968), and Bagshaw, Kimble, and Pribram (1965), have observed the disappearance of phasic heart rate responses during an orienting task, after amygdaloid lesion.

A number of investigators have demonstrated that components of

the orienting response may be used to index memory consolidation and to differentiate between semantic and non-semantic processing. Luria and Vinogradova (1959) have distinguished between acoustic and semantic encoding of stimuli on the basis of the vascular component of the orienting response. A systematic relationship between memory trace consolidation and arousal has been reported by several researchers (Kleinsmith and Kaplan, 1963 and 1964; Walker and Tarte, 1963; Corteen, 1969). Briefly, these authors found that items which elicit a large galvanic skin response were better retained after a long-term retention interval than other items.

In accordance with the evidence outlined above, the following proposition may be entertained: If semantic and non-semantic tasks regulate attention differentially, and impose different demands on the perceptual/cognitive system, then this situation should be reflected in concomitant heart rate and galvanic skin response changes: and if intentional learning involves a processing dimension or strategy over and above that involved in incidental learning (eg., elaborative rehearsal), then this difference should also be reflected in associated heart rate and galvanic skin response changes.

If it can be demonstrated that autonomic response measures are meaningfully related to the behavioral indices of levels of processing, then one more step will have been gained toward an operational definition of the abstract concept of levels of processing. This contribution should of course, enhance the empirical status of this concept, thus increasing its potential to excite new vistas for

theory and application in the learning-instructional process.

The major purpose of this study was to determine whether autonomic response change could be used reliably to index "depth" of processing, and the incidental-intentional distinction. A subsidiary aim of the present study was an attempt to replicate (with design modifications) the behavioral findings of Craik and Tulving's (1975) experiments 3 and 4. An attempt was also made to examine in more detail the possible intricate functional relationships which exist between recall on the one hand, and on the other, levels of encoding and congruous-incongruous responses within the incidental and intentional learning paradigms.

CHAPTER II

SELECTIVE REVIEW OF THE LITERATURE

Levels of Processing and Memory

Over the last five years, there has been a growing tendency among theorists to shift their focus of attention away from the mechanics of the multi-store models to the mental operations which regulate formation and consolidation of the memory trace. Before examining this new concept, it may be helpful to briefly review the basic structure and operations of the temporally structured models.

The basic structure of the "box" model was originally proposed by Broadbent (1958) and modified by a number of writers (Waugh and Norman, 1965; Peterson, 1966; and Atkinson and Shiffrin, 1968). These authors postulated three consecutive storage mechanisms which comprised the memory system. They are: sensory store, short-term store, and long-term store. The basic mode of operation of this model involves the transfer of information from one discrete store to another. Items enter the sensory register where it decays rapidly unless they are transferred to a limited capacity processor. In this second holding mechanism, items could be maintained by recycling them for some time after perception. The product of this operation is short-term memory. From the short-term storage mechanism items may be transferred to a

more durable long-term store. In this model, retention was primarily a function of the length of residence of items in the various stores. Some minimal attention was given to processes in this model, but its major concerns were with structure and capacity of the various stores.

Craik and Lockhart (1972) in a theoretical paper, questioned the adequacy of the basic multi-store model, and proposed an alternative model of memory in terms of levels of processing. The major thrust of their criticism was focussed on two as yet unresolved questions. First, they questioned the utility of the proposed distinguishing features of each storage mechanism. They especially questioned the notion advanced by Conrad (1964) and Baddeley (1966), that short-term encoding is characterized exclusively by acoustic encoding, whereas, long-term encoding is characterized by semantic activity. The second criticism is directed at the ambiguity surrounding the nature of capacity limitation. Whereas this notion is generally believed to be a storage limitation, Craik and Lockhart (1972) argued that it must be a function of the type of processing in which the processor is engaged. Furthermore, they claimed that the central processor which maintains information in short-term memory is neutral with respect to its coding characteristics. They added that such factors as task demand and subject controlled variables bias the coding operation of the processor. Finally, Craik and Lockhart objected to the segmentation of the memory system.

As an alternative to the multi-store models, they proposed a new orientation to memory research, which is primarily concerned with the

qualitative aspects of encoding operations performed on the stimulus. This model is called the levels of processing model. If empirical evidence support this model, then a number of explanations generated by the multi-store models will be invalidated.

The Levels of Processing Model.

In 1972, Craik and Lockhart proposed a theoretical framework which described the processing of stimuli by means of a continuum of analysing operations. This formulation proposed that impinging stimuli are processed through a hierarchically organized series of levels. First impinging stimuli are subjected to physical analysis and are then processed progressively deeper to a more semantic level. Imposed on this "basic memory system" were two types of rehearsal: maintenance rehearsal, and elaborative rehearsal. The function of maintenance rehearsal is merely to maintain processing activity at one level of analysis. It involves the repetition of encoding operations already accomplished, which does not necessarily lead to improved retention. Conversely, elaborative rehearsal has a definite trace-strengthening function which leads to improved memory performance.

It should be noted that the general concept of levels of processing is not a new one. Several writers before Craik and Lockhart (1972) have agreed that perception involved the rapid analysis of stimuli through a number of qualitatively distinct levels (Moray, 1959; Neisser, 1960; Triesman, 1964; and Sutherland, 1968).

More specifically, with regard to levels of perceptual analysis and memory, Moray (1959) and Triesman (1960) demonstrated that items presented to a rejected channel are processed at a relatively shallow level, and consequently, are not recognized on a subsequent memory test. However, although many notions similar to the Craik and Lockhart (1972) model have been suggested before, their formulation was the most comprehensive and organized statement concerning the levels of processing phenomenon.

In general, the major arguments of the 1972 formulation remain essentially the same, but some of the original ideas have recently been modified, refined, and extended (Lockhart, Craik, and Jacoby, 1975; Craik and Jacoby, 1975; and Craik and Tulving, 1975). Two major changes were made to the existing model. The first change was an attempt to clarify and elaborate the nature of levels of processing. The second concerned the distinction between episodic and semantic memory.

The general idea of processing depth and its influence on retention was retained as a crucial aspect of the model. But the original notion that incoming stimuli were subjected to a fixed sequence of analyses along a unidimensional continuum, was largely rejected. Instead of a "processing continuum", it was postulated (Lockhart, Craik, and Jacoby, 1975; and Craik and Jacoby, 1975) that encoding may take place laterally and/or vertically through relatively distinct, but hierarchically arranged analyzers. The term "domain" was borrowed from Sutherland (1972) to describe these various distinct

levels, and "spread" was adopted to describe elaborative processing within a specific domain.

By introducing the above modification, the meaning of depth was extended and made more specific. It was still held, however, that relatively shallow levels of processing precede deeper semantic levels of processing. But now it was suggested that deeper analysis of stimulus may refer to two qualitatively distinct types of encoding operations. First it may refer to the vertical hierarchical direction of stimulus encoding, that is from processing at a shallow structural domain to a deeper semantic domain. Secondly, greater depth of processing may mean further elaboration of encoding within a single "qualitatively coherent" (Lockhart, Craik, and Jacoby, 1975. p. 6) domain. This extended meaning of processing depth implies that the target domain of elaborative processing may be defined in terms of the orienting task.

With respect to the episodic-semantic distinction, Lockhart, Craik, and Jacoby (1975), noted that; semantic memory may be defined as the "pattern recognition system." It is also the storehouse of generalized knowledge. In this respect it interprets incoming stimuli by means of elaborate cognitive operations. On the other hand, episodic memory is that part of the perceptual/memory system where the records of specific events and episodes are stored. It is comprised of a series of "temporally-ordered" traces of the most recent additions to the perceptual/memory system. It is this series of temporally-ordered traces which may eventually become incorporated

into the more permanent and structurally elaborate memory system.

Recently, Craik and Tulving (1975) addressed the issue of incidental vs intentional learning in memory. Their general conclusion was that instruction to learn has an insignificant effect on retention. This generalization was explicit in the statement that; "The operation carried out on the material, not the intention to learn as such, determine retention." (p. 269). These ideas regarding the intentionality dimension and memory seem to have been adopted from Postman (1956 and 1964) paper. However, Postman's statement regarding instruction to learn and memory, was more guarded than Craik and Tulving's (1975). He claimed that the more meaningful the materials, the less the difference between intentional and incidental learning in memory performance.

Evidence Relating to the Levels of Processing Model.

Few studies have subjected the model to a comprehensive empirical test. To the suthor's knowledge, only two studies have attempted such an examination. The first by Craik and Tulving (1975), and the second by Lawson (1976). In their study, Craik and Tulving claimed to have resoundingly established the robustness of the model. The Lawson experiments on the other hand, did not produce such unequivocal support. The problem of the adequacy of the definition of depth and spread of processing loomed largely in the latter experimental results.

Craik and Tulving (1975) described a series of experiments which were carried out to test the major postulates of the levels of processing model. In experiments 1 to 4 of this series, they claimed to have provided "the empirical flesh for the theoretical bones of the arguments" (p. 278), advanced by Craik and Lockhart (1972). These first 4 experiments were exclusively concerned with testing the hierarchical or vertical dimension of levels of processing. Indeed, the results of these experiments seemed to provide strong and consistent support for the model. Using both response latency to specific orienting questions and retention as indices of depth of encoding, the results of the experiments showed a linear relationship between levels of encoding on the one hand, and decision latency and memory performance on the other. The results showed that decision latency and recall and recognition performance rose systematically from shallow physical encoding to phonemic encoding, to semantic encoding.

With respect to intradomain or lateral processing elaboration, only a restricted test of this hypothesis was carried out (experiment 7). The within domain spread of processing examined in this experiment was exclusively related to the semantic domain. The orienting tasks were sentences with a missing word, and the degree of within domain encoding elaboration was manipulated by presenting three levels of sentence complexities. The results of this experiment revealed that the processing of a word within the context of more complex sentences leads to greater recall, but only in the case of congruous target words.

The data from the Lawson (1976) experiments were not as clear-cut nor as supportive of the model as those reported by Craik et al (1975). These data also pointed out some notable deficiencies in the definition of the core concepts of depth and spread of encoding. In these experiments, Lawson (1976) not only attempted to distinguish between levels of processing, but also attempted to distinguish between the concepts of depth and spread of encoding. Experimental tasks were designed to induce processing either to a specific level or elaboration within a specific domain. This approach is in contrast to the limited test of spread of processing restricted to the semantic domain by Craik and Tulving (1975).

The data from this study showed that, in terms of a general semantic-nonsemantic distinction, the levels of processing model was supported. But a more detailed examination of these data yielded evidence inconsistent with the model. The results challenged the distinctiveness of the hierarchical arrangement of domains as presented by Craik and his collaborators. Specifically, Lawson's findings showed that while semantic encoding is demonstrably superior to physical and phonemic encoding in terms of retention, the physical-phonemic contrast is minimal or nonsignificant. These negative findings were derived from tests of both depth and spread of encoding.

An important, though unpredicted outcome from testing the levels of processing model (Craik and Tulving, 1975), was the discovery that words given a positive response were associated with greater retention than words given a negative response. This finding

of higher recall performance for "yes" response words over "no" response words was consistent and very pervasive in the Craik and Tulving (1975) series of ten experiments. This finding is not a new one since Schulman (1974) reported similar results.

The explanation given by Craik et al (1975) for this phenomenon in recall seems to be quite consistent with the levels of processing view. They, like Schulman (1974), argue that congruous responses to the orienting questions are compatible with existing cognitive structures and consequently, lead to more elaborative encoding. This elaborative encoding leads to more distinctive and unique memory traces which in turn facilitates retrieval. In contrast, incongruous responses to the orienting questions result in somewhat abortive encoding activity. This effect leads to poorer recall.

The above suggestion is consistent with Meyer's (1970) analysis of true/false reaction times to propositions of the nature all S are P. Meyer concludes that such a proposition requires one or two stages of processing. During stage 1, S and P are examined for evidence of "semantic overlap". It is only when such evidence is found does testing proceed to the second stage of processing in order to determine whether S is wholly contained in P. The operations during Meyer's second stage may presumably be the type of activity which takes place in encoding of congruous queries.

In contrast to the Craik and Tulving (1975) results, Lawson (1976) found no consistent superiority of retention for words given a

"yes" response over those given a "no" response. Although the yes/no difference in recall was evident in the semantic tasks, this was not the case for either the physical or phonemic tasks.

With respect to the issue of intentional vs incidental learning, it was pointed out previously, that Craik and his collaborators minimize the influence of intentional learning despite evidence to the contrary. Even the results from their own experiments contradict the notion that "it is not the intention to learn that determines retention." (Craik and Tulving, 1975. p. 268).

The evidence bearing on this issue (eg., Postman, 1956; Watson and Jenkins, 1973; Jacoby and Goolkasian, 1973; and Lawson, 1976) indicates that there is no need to dismiss the intentional effect from the levels of processing model. On the contrary, the evidence suggests that incorporating this dimension into the model will extend its explanatory power. The available evidence supports the idea that intention to learn may be conceived as an extra dimension of encoding over and above those induced by incidental instructions. This additional dimension of encoding seems to be more beneficial to shallow domain processing than to deeper semantic processing. A number of studies (eg., Jacoby and Goolkasian, 1973; Zerdy, 1971; Triesman and Tuxworth, 1974; Watson and Jenkins, 1973; and Lawson, 1976) have provided limited but encouraging support for this idea.

Jacoby and Goolkasian (1973), using the incidental learning paradigm in an experiment, required subjects to judge pairs of words

as being either related or unrelated on a specified acoustic or semantic dimension. In the intentional learning condition, subjects received the same words but were instructed that a recall test would follow presentation. The results of this study showed that instructions to learn enhanced recall and clustering of acoustically related words, but had no effect on the usefulness of semantic relationships. Regardless of the learning instructions, semantic relationships were more effective than acoustic ones. In a similar experiment, Watson and Jenkins (1973) observed that when subjects performed a semantic orienting task, recall was not significantly different from an intentional control group which was presented with the same items, but performed no orienting tasks. Lawson (1976) reported some evidence which indicated that shallow level of processing benefitted more from preparation for recall. One reasonable interpretation of these findings is that in the intentional learning condition, "shallow level items" are subjected to further intradomain elaborative rehearsal; whereas, in the already deeply processed "semantic items", there is little scope for more of this type of rehearsal.

In the levels of processing model, rehearsal is broken down into two component processes. This notion of two types of rehearsal has received substantial support (eg., Jacoby, 1973; Craik and Watkins, 1973; and Mazuryk, 1974). For example, an experiment by Mazuryk (1974) illustrates the distinction between maintenance and elaborative rehearsal processes. In this experiment, subjects were presented with 14-word lists for immediate free recall. In all cases, the first ten words of each list were silently learned, but the last four words were

studied in one of three ways: silent learning, overt rehearsal, and by the generation of verbal associates to each list word. The immediate free recall condition was followed by a final free recall of all lists. The results showed that while "verbal associate" learning was detrimental to immediate recall, it yielded superior recall for these items in the final test. The results indicate that maintenance activity at one level of analysis is facilitative of immediate recall, but with elaborate analyses, long-term retention benefits.

In concluding this section, it should be noted that the two major tests (Craik and Tulving, 1975; and Lawson, 1976) of the levels of processing model have yielded conflicting results, whereas, Craik and Tulving reported overwhelming support for the distinctiveness of three hierarchically arranged processing levels, Lawson's results question this distinctiveness of the processing levels. Also, the general finding of superiority of retention of positive response words in all ten experiments reported by Craik and Tulving, was not substantiated in Lawson's study. Craik and Tulving claimed to have established the robustness of the basic phenomenon of depth of processing. This claim is based on the fact that they obtained essentially the same pattern of results in all ten experiments under varying experimental conditions. This robustness did not seem to generalize to the Lawson's study. With this in mind, one cannot entirely discount the possibility that methodological differences between the two studies may have partially contributed to the differential results obtained.

Craik and Tulving's experiments 1 to 8 comprised the major critical empirical test of the levels of processing model. In all of these experiments, subjects were individually tested in a reaction time task paradigm, in which the imperative stimulus had a very limited exposure time (200 m/sec.). Whereas, in the Lawson study, subjects were group tested in a non-reaction time situation. At this point one cannot be sure, but it is possible that the reaction time paradigm may be the most effective design for examining the nature of levels of processing. Is it possible that increased vigilance and less distraction in the former study might have partially contributed to the differences in finding? On the other hand, if the basic phenomenon of depth of processing is as robust as Craik and his colleagues claimed, methodological differences of such magnitude could have hardly accounted for the incongruent results.

From the evidence reviewed above, one may conclude that the problem of indexing depth of processing still remains largely unresolved. Several ways of indexing depth of encoding have been suggested. For example, Bower (1975) and Herriot (1974) advocated that depth be indexed both in terms of the number of attributes analysed. Bower and Carling (1975), similarly proposed that the amount of detail attended to may serve to define depth. Unfortunately however, the preceding suggestions have not been accompanied by empirical definitions or ways of arriving at such definitions. According to Craik and his colleagues, reaction time may be used with caution to index processing depth. Their 1975 experiments provided partial support for this notion. The results of these experiments

showed that there was a linear relationship between response time and levels of processing. However, they hastened to add that time cannot always be taken as an absolute measure of depth. Since highly complex but familiar stimuli may be encoded more rapidly to a deep cognitive level than less complex but novel stimuli. However, they maintain that within one class of materials or with a specific stimulus, deeper encoding will require more time. In spite of this attempt to index depth however, the concept still remains unclear.

It is hoped that the psychophysiological methods employed in the present study, together with a closer examination of the behavioral data, will provide some insights into levels of processing within both incidental and intentional learning conditions.

Autonomic Reactivity In Information Processing

Over the past decade, a number of developments have emerged in the field of psychophysiology which have important implications for the use of physiological measures as indices of psychological processes. Many abstract concepts related to attention and cognition, and which cannot be directly measured, have presumably been indexed by physiological measures. Prior to these developments, such concepts as: expectancy, anticipation, uncertainty, effort, and mental load, were virtually undefined in the psychological literature. One might hasten to add that psychophysiological research has not eliminated these problems of definition, but it has at least provided in some cases, reliable indices of these abstract concepts.

As an illustration, research on cortical evoked potential has reliably indexed preparatory or anticipatory activity. The contingent negative variation (CNV), a negative slow potential, has been shown to precede forewarned events which require concerted attention or response to an imperative stimulus. On the other hand, the P300, a positive component of the evoked potential which occurs with a model latency of approximately 300 m/secs is associated with reduction of: uncertainty, anticipation, and decision making activity (Walter, Cooper, Aldridge, McCallum, and Winter, 1964; Hillyard, Squires, Bower, and Lindsay, 1971). Other authors (eg., Bernstein, 1969 and 1975; and Germana, 1968) studying the GSR, have demonstrated that

central mechanisms which mediate the production and habituation of the orienting response are concerned with much more than simple stimulus novelty per se. These studies of the GSR revealed that these central structures subject all stimuli - novel or old, to continuous scrutiny in order to evaluate significance. With respect to autonomic activity and information processing, a number of investigators (eg., Lacey et al, 1963 and 1967; Tursky, Schwartz, and Crider, 1970; Coles and Duncan-Johnson, 1975) have demonstrated a consistent relationship between cognitive activity and autonomic response topography. Furthermore, direct research on the central attention and information processing systems, has revealed a close coupling of these central systems to the peripheral autonomic response systems. This line of research (eg., Pribram et al, 1975; Vinogradova, 1970) points to the potential heuristic value of physiological variables in helping to elucidate the complexities of central mediation.

The emergence of these developments was accompanied by a new concept of the orienting response and its concomitant autonomic indices. Researchers in the field of psychophysiology have to recognize that if psychophysiological measures are to be more than of trivial interest, then such simplistic conceptions of the OR as a simple unidimensional phenomenon must be abandoned. Central control of peripheral autonomic responsivity is a fact which cannot be represented along a single dimension of intensity as proposed by Malmo (1959). In commenting on this new conception of the OR, Lacey (1967) has emphasized that "........... activation or arousal processes are not unidimensional but multidimensional and that

activation processes do not reflect just the intensive dimension of behavior, but also the intended aim or goal of behavior." (p. 25).

There is a growing feeling among many theorists (eg., Lacey et al, 1967 and 1970; Maltzman and Mandell, 1968; Graham and Clifton, 1966; and Bernstein, 1975) that it would better suit the complexities of the central mediator to have several different responses available, each presumably with its own unique functional characteristic, rather than a single, gross and undifferentiated response pattern. It is known that within the experimental laboratory, the nature of the OR is determined by a multiplicity of factors. A well-known case in point is the heart rate response and its differential association with shifts in attention (Lacey, 1967). Other studies (eg., Graham and Clifton, 1966; and Graham and Jackson, 1970) have shown that a number of specific factors such as stimulus parameters, task demands, and subject control or state variables, all influence the nature of the OR.

Therefore, given the amounts and kinds of central nervous system contributions to the OR, it may be suggested that a variety of physiological measures may be desirable in the study of complex psychophysiological relationships. This is desirable since it has been reported that a variety of physiological responses may better reflect separately mediated cognitive processes (Ohman, 1971; Prokasy and Abel, 1967; and Prokasy and Kumpfer, 1973). It may be concluded then, that the OR can no longer be conceived as merely a simple reactive reflex to novel stimulation, but as a reflection of

active search and thinking (Das, 1975). This view is very consistent with current theorizing and empirical evidence. The consideration of utilizing several psychophysiological response characteristics as indices of information processing requirements, is an important one in this study.

HR Change in Information Processing.

Of all the autonomic indices which are used to monitor the orienting response, none has been the focus of more theoretical and research effort than the cardiovascular component. The emergence of this special status for heart rate change was primarily due to two major psychophysiological formulations. They are: the "intake-rejection" hypothesis of Lacey and his collaborators (Lacey, 1959; Lacey, Kagan, and Moss, 1963), and the "cardiac-somatic" hypothesis of Obrist et al (Obrist and Webb, 1966; Obrist and Webb, 1967; and Obrist, Webb, Sutturer, and Howard, 1970).

These two theoretical frameworks have emphasized the dynamics of the facilitatory and inhibitory characteristics of heart rate change during shifts in attention. In doing so, these formulations have helped considerably to modify the earlier simplistic, if not misleading, unidimensional models of activation (Duffy, 1951; and Malmo, 1959). Without the insights offered by these two models, it is doubtful that any special interest would have been attached to cardiac change as it relates to attention. The Lacey and Obrist models have

demonstrated their heuristic value in clarifying and reinterpreting a number of psychophysiological relationships. For example, the previously reported, but unexpected findings of heart rate deceleration during conditioning (Shearn, 1961; McDonald, Stern, and Hahn, 1963) were plausibly accounted for within the context of the Lacey's hypothesis. It may be suggested that these two hypotheses show a great deal of promise in helping to provide some independent indices of levels of information processing.

The Intake-Rejection Hypothesis.

Of the two major hypotheses, the intake-rejection hypothesis has been subjected to more testing and controversy (Elliott, 1972; Hahn, 1973) than the cardiac-somatic model. The hypothesis states that elevations in heart rate and blood pressure are associated with and instrumental in reducing the effect of external stimulation. This state is associated with, and even facilitates attention to mental operations. Correspondingly, heart rate deceleration and lowered blood pressure are associated with and instrumental in facilitating attention to the external environment.

The intake-rejection hypothesis was neither the first nor the only one to propose a differentiation between externally and internally focused attention. Nor has this phenomenon been exclusively associated with heart rate change. The phenomenon of "ideational vs sensory" cardiac responses was empirically identified by Darrow in 1929. In

1959, Schactel, a metaphysical-developmental psychologist advocated two similar types of attentional involvement. Hernandez-Peon (1964) suggested an analogous neurophysiological hypothesis. He and his co-workers observed that the visual evoked potential to light flashes was significantly attenuated when subjects were engaged in solving arithmetic problems or in verbal activity.

Lacey et al (Lacey, Kagan, and Moss, 1963; Lacey, 1967; and Lacey, 1970) have attempted to anchor their hypothesis on selective corroborative neurophysiological evidence (Bonvallet and Allen, 1963). They have consistently cited these experimental findings in support of their hypothesis. According to this study, there exists a cardio-cascular feedback loop to the brain which serves to modulate intake or rejection of external stimulation. The study revealed that increases in heart rate and blood pressure activate the baroceptors in the aortic arch of the carotid sinus. Impulses from this activation are then transmitted along a negative feedback pathway to the inhibitory center in the reticular activating system. The effects of these impulses on the reticular activating system causes a shift in sensory related electrocortical activity from a relatively excitatory to a relatively inhibitory state. Other related neurophysiological studies (Bonvallet and Block, 1961; Bonvallet, Dell, and Hiebel, 1954) have observed that lesions to the reticular inhibitory mechanism or severence of the cardiac-reticular feedback pathway, results in a prolongation of the effect of sensory input on electrocortical activation.

Criticisms of the intake-rejection hypothesis has been concentrated on the ascribing of causality to cardiovascular change (Elliott, 1972; Hahn, 1973). A subsidiary concern in these criticisms is with the inadequate specification of stimulus or task parameters which determine the direction of heart rate change. In spite of these short-comings, the hypothesis has generated sufficient evidence to entrench the notion that heart rate deceleration provides a reliable index of externally focused attention; while heart rate acceleration reliably indexes attention to internal cognitive activity.

Evidence for the Intake-Rejection Hypothesis.

In a series of experiments, Lacey et al (Lacey, Kagan, Lacey, and Moss, 1963) have demonstrated that heart rate acceleration is significantly associated with those tasks of a problem solving sort, which require internal cognitive elaboration. Such specific tasks like mental arithmetic, reversed spelling, and the covert making up of sentences were significantly related to heart rate acceleration. While tasks requiring attention to environmental inputs like photic flashes, white noise or dramatic recitation, produce significant cardiac deceleration. On the other hand, tasks requiring the combined processes of environmental reception and internal cognitive elaboration produced an intermediate heart rate change.

Consistent with the above findings, Tursky, Schwartz, and Crider (1970), reported evidence which supported the hypothesis. In their

study, 15 subjects performed a paced digit-transformation task at two levels of difficulty under both overt and covert response requirements. The results showed that the time-locked recordings of heart rate deceleration was manifest during the information intake phase of the task (i.e., digit presentation). Whereas, the digit transformation stage was characterized by significant heart rate acceleration. Furthermore, response magnitude of heart rate measures were significantly increased in the more difficult condition.

Jennings (1971) in a developmental study, employed the intake-rejection hypothesis to examine Piagetian levels of perceptual and cognitive functioning. The primary purpose of the experiment was to determine whether changes in cardiac reactions could serve as reliable indices of Piagetian levels of cognitive development. The subjects were 78 boys from kindergarten to third grade. In general, this study found that cardiac change appeared to be a joint function of externally focused attention and cognitive operations. Additionally, it was found that perceptual tasks produced significant deceleration in all subjects. In contrast, all cognitive tasks produced initial cardiac deceleration followed by more pronounced and prolonged cardiac acceleration. Like the Tursky, Schwartz, and Crider (1970) findings, Jennings reported a positive relationship between the amount of cardiac acceleration and levels of performance in conservation of length and a verbal version of class inclusion, but not in a pictorial version of class inclusion.

In an experiment which involved passive viewing or rating of

unpleasant stimuli on a seven point continuum, Hare (1972) reported results which are consistent with the Lacey's hypothesis. The two major findings of this study are: non-raters (passive viewers) responded with cardiac deceleration, while the raters' response was predominantly cardiac acceleration. In order to determine whether cardiac acceleration was primarily due to the motor response requirement, another group of subjects were instructed to button-press after each slide presentation. The cardiac response of this group was essentially the same as for the passive viewers. These data are consistent with the notion that the requirement to rate the stimuli was associated with the process of stimulus categorization or cognitive elaboration.

In a recent paper, Coles and Duncan-Johnson (1975) have sought to extend the explanatory power of the intake-rejection hypothesis. Since the present study examined the cardiac change-information processing relationship within an experimental and theoretical framework similar to that adopted by the above researchers, it may be appropriate to examine their theory and evidence in some detail. These authors proposed a two-component model of orienting to account for the presence of both an accelerative and a decelerative component of cardiac change customarily observed during the fore-period of warned reaction time or detection tasks. Prior to this proposition, the accelerative limb of the heart rate response in these paradigms was either virtually ignored, or merely accounted for in terms of defence or startle, due to stimulus parameters or subject states. For example, Graham and Clifton (1966) have attempted to reconcile

the conflict between Sokolov's assumption that cardiac acceleration is the OR component, and Lacey's assertion that cardiac acceleration is associated with environmental rejection. Their effort led them to conclude after an extensive literature review, that deceleration is the major component of the OR. It should be noted that this conclusion was arrived at from studies of heart rate change exclusively to non-signal stimuli. None of these studies employed a signal reaction time or detection task. Presumably, these tasks involve much more complex psychological processes.

Coles et al (1975) suggested that the sequential accelerative-decelerative heart rate response observed in the fore-period of a reaction time task, reflects two distinct psychological processes. It is further claimed, that despite this functional distinction, these two components are inter-dependent. It is argued (Coles, 1974; Duncan-Johnson and Coles, 1974; and Coles and Duncan-Johnson, 1975) on both theoretical and empirical grounds, that the cardiac acceleration which follows a warning signal may reflect the amount of stimulus significance in terms of information processing and/or decision making activity. Furthermore, the magnitude of this acceleration may be an index of the degree of processing and decision making demands. Needless to say, this psychological process associated with the initial accelerative limb is analogous to Lacey's internal focusing of attention during cognitive activity. The second psychological process of this two-component model which is associated with cardiac deceleration, reflects both preparation to respond and detection activity. It has been demonstrated (e.g., Coles, 1974;

and Coles and Duncan-Johnson, 1975) that the magnitude of this response varies as a function of information processing, detection, and response requirements.

Further support for this concept of cardiac orienting, as it relates to information processing and decision making requirements was obtained in two experiments (Coles and Duncan-Johnson, 1975). In these experiments, heart rate and electromyographic measures were recorded while subjects performed two series of tasks (easy and difficult). These tasks involved sequential information processing activity. Each trial consisted of a warning light, three successive tones, and a respond light. Each of these consecutive stimuli was separated by a 6-second interval. In the first experiment, subjects responded to an imperative stimulus only if the three preceding tones were of different frequencies. In experiment 2, subjects responded only if two of the three preceding tones were of the same frequency. Results from both experiments showed that heart rate acceleration increased as a function of the significance of the tone which determined the decision. Subsequent cardiac deceleration was observed only if a response execution was required to the imperative stimulus. In another experiment (Coles, 1974), it was also shown that both components of heart rate change during the fore-period increased as the task became more demanding.

The two-component proposal have gained support from previous studies using the basic reaction time paradigm. For example, Porges, Stamps, and Walter (1974), have formulated theoretical arguments for

a relationship between initial cardiac acceleration in the foreperiod and the information value of stimuli. A number of researchers (e.g., Das and Bower, 1973; and Jennings, Averill, Opton, and Lazarus, 1970) have observed that the heart rate accelerative response to a warning signal was a positive function of the amount of uncertainty about which of two responses may be required. The two-component model implies that manipulations of uncertainty involve manipulations of stimulus information value and consequently, these effects determine the amount of cardiac acceleration. This model bears some resemblance to the two-component model of the OR presented by Germana (1968). According to this proposition, the central structures responsible for producing the OR are concerned not only with processing stimulus parameters, but also in determining the associated response characteristics as well. According to Germana, the OR leads to the resolution of two questions: What's it? and What's to be done? Germana further suggests that autonomic response characteristics may differentiate between these two questions.

As was pointed out before, the two-component hypothesis is particularly relevant to the present study, since information processing and decision making requirements are manipulated in a modified reaction time paradigm in this study. Also, in the present study, stimulus significance is additionally manipulated along the intentionality dimension.

<u>The cardiac-somatic hypothesis</u>.

An important difference between this hypothesis and the intake-rejection hypothesis is that, whereas the latter hypothesis attributes causality to cardiovascular changes, the cardiac-somatic hypothesis sees heart rate change as effects rather than causes. The cardiac-somatic hypothesis of Obrist and his colleagues (Obrist, 1968; Obrist and Webb, 1967; Obrist, Webb, Sutturer, and Howard, 1970) proposes that the direction of heart rate change is primarily a function of the amount of ongoing general somatic activity.

The hypothesis claims that cardiac and somatic events are centrally linked and their activity co-vary during focused attention. The hypothesis suggests further, that the psychological processes of information processing and preparatory activity will be enhanced or inhibited depending on the amount of "noise" (Venables, 1973) in the cardiac-somatic system. That is, "quieting" of the system is associated with increased detection of external stimuli and facilitation of response execution, whereas, variability in the system leads to a reduction in such performance.

Evidence for the cardiac-somatic hypothesis.

Obrist and his collaborators (Obrist, Sutturer, Howard, Hennis, and Muriel, 1968; Obrist, 1973; Webb and Sutturer, 1969; and Obrist, Webb, Sutturer and Howard, 1970) meticulously tracked second by second ongoing somatic and cardiac activity during the fore-period of warned reaction time tasks. Among the somatic measures recorded

in these studies were: spontaneous EMG bursts from the chin area; eye movements and eye blinks; and frequency and amplitude of respiration. The findings of all these studies consistently showed that increases or decreases in somatic activity were closely associated with corresponding increments or decrements in heart rate.

Obrist et al (1970) also attempted to evaluate the behavioral significance of the cardiac response as it pertains to both the intake-rejection and the cardiac-somatic hypothesis. It will be recalled that, the basic postulate of the intake-rejection hypothesis is that cardiac deceleration is an instrumental act, the occurrence of which facilitates detection and response execution. This differential evaluation of the two hypotheses was based on the following reasoning: if cardiac deceleration is linked to somatic effects, in that it is a peripheral manifestation of a central process which inhibits ongoing somatic activity, then blocking the cardiac response should not affect the facilitatory nature of this process. If on the other hand, heart rate deceleration has an instrumental facilitatory effect on stimulus detection and performance via the proposed afferent feedback mechanism, then the blocking of cardiac deceleration should reduce the hypothesized facilitatory effect.

A reaction time experiment was designed to test this argument. The fore-periods of this reaction time study varied randomly between 2, 4, 8, and 16 seconds. The cardiac response was pharmacologically blocked in 31 subjects by an injection of atropine sulfate. The

results of this experiment clearly supported the cardiac-somatic linkage hypothesis, in that there was no reliable change in performance when the cardiac response was blocked. This hypothesis has also gained support from a number of other sources. For example, Obrist et al (1970), and Johnson and Campos (1967) have suggested on both theoretical and empirical grounds that, the heart rate acceleration observed during cognitive activities may be a function of somatic activity produced by the covert verbalizations required by these tasks. This notion is reinforced by the findings of several studies (e.g., Sokolov, 1967; McGuigan, 1970) which investigated the relationship between somatic activity and mental activity. These studies have found a significant increase in covert verbal activity during such cognitive tasks as; mental arithmetic and rehearsal.

Before concluding this section, it should be noted that the cardiac-somatic hypothesis also suggests that motivational significance of stimulus events is highly related in a consistent fashion to both heart rate and somatic changes (Elliott, 1972). In the present study, motivational significance of stimuli is manipulated and heart rate change was examined within this context.

The Galvanic Skin Response in Information Processing.

The galvanic skin response (GSR) has been the most widely used physiological measure to index the OR. Until recently, the GSR was conceived as a primitive and ubiquitous unconditional reflex induced

by simple stimulus change. Increasingly, there is acceptance of the view that the OR represents a complex of information processing and decision making activity. Correspondingly, the conceptual model of the GSR is changing. Researchers have begun to recognize that there is differentiation within this psychophysiological channel. A major influential factor in this altered view of the GSR was the findings from a group of studies on skin conductance during conditioning (Lockhart, 1966; Prokasy and Ebel, 1967; and Grings and Sukoneck, 1971). These researchers studying the GSR during relatively long CS-UCS intervals, have reported three distinct consecutive responses associated with such intervals. There is an initial GSR to the CS, one anticipating the UCS, and an unconditioned GSR following the UCS.

Ohman (1971) has carried out further analyses on this three-component GSR. In a recent factor analytic study, Ohman (1972) reported a consistent three-factor pattern comprising the above mentioned response components. Ohman (1971) suggests that these three response components are independent and may be correlates of three separately mediated psychological processes.

There are impressive theoretical arguments, clinical and experimental evidence (e.g., Douglas and Pribram, 1966; Vinogradova, 1970; Pribram and McGuinness, 1975; Bernstein et al, 1975; Picton and Hillyard, 1974; and Gruzelier and Venables, 1972) which support the notion of complex GSR characteristics associated with information processing. Evidence from some of these studies indicates that, information processing at various levels of the brain is regulated

by a group of central interacting attentional systems. Other studies have shown that these attentional systems also control electrodermal activity. Pribram and McGuinness (1975) have proposed a complex of three interacting attentional systems which regulate not only the central information processing mechanisms, but also the GSR. These systems consist of: the limbic forebrain complex which includes control circuits based in the amygdala controlling arousal; the basal ganglia mediating activation; and the hippocampus coordinating arousal and activation.

That these three attentional systems control the GSR is well documented by the following studies. Yokato, Sato, and Fujimori (1963), and Yokato and Fujimori (1964), found that low intensity stimulation of the hippocampus had an inhibitory effect on skin potential and blood pressure. Wang (1964) also noted that stimulation of the hippocampus had an inhibitory effect on skin conductance activity. Pribram and McGuinness (1975) reported that lesions to the monkey's hippocampus result in more rapid termination of the phasic skin response. Concerning the amygdala, which regulates arousal, the evidence linking it with electrodermal activity is convincing. For example, Holdstock (1969 and 1970) reported that the skin conductance orienting responses of monkeys and rats with lesions of the amygdala failed to show the GSR characteristics of orienting and habituation. Bagshaw et al (1965 and 1968) have shown that amygdaloid lesions lead to reduced amplitude of electrodermal responses during orienting.

On the basis of a hypothesized attention-information processing

deficit model, the skin conductance response has been used extensively to characterize different pathological populations. For example, Gruzelier and Venables (1971 and 1972) have used a constellation of GSR characteristics to distinguish institutionalized from non-institutionalized schizophrenics and also to distinguish these two populations from normals. Within the context of a hypothesized attention-information processing deficit model, electrodermal activity has been used to characterize varying degrees of mental retardation (Luria, 1973; Das and Bower, 1971) and the hypo-hyper-kinetic syndrome (Satterfield and Dawson, 1971).

The empirical and clinical evidence reviewed thus far, suggests an important relationship between the attention and information processing system on the one hand, and electrodermal activity on the other. This relationship among the central attentional systems, information processing system, and electrodermal activity, suggests that the GSR may reliably serve to index levels of processing. Currently available neurophysiological evidence (e.g., Picton and Hillyard, 1973; Picton and Hillyard, 1974) is consistent with such a notion. For example, Picton and Hillyard (1974) were able to delineate levels of processing by a detailed examination of the auditory evoked potential recorded at all levels of the auditory system. These researchers found that the characteristics of the early components of the evoked potential indicates that the physical structure of all auditory stimuli are analyzed in the primary auditory system regardless of their signal value. However, when further elaboration of the stimulus is warranted, a second, more

diffuse auditory system, comprising of the reticular formation, medial thalamus, and association cortex become involved. This distinction between low level analysis and more elaborate processing was based on the amount and type of early and late evoked components recorded at many levels of the auditory system. The above study was carried out on human subjects, who were either instructed to attend to or ignore specific auditory stimulation.

Could the GSR likewise serve to distinguish between various levels of analysis? To the author's knowledge, no previous study has attempted to answer this question directly. However, the evidence linking the GSR and the central attention and information processing mechanisms, together with the neurophysiological evidence just reviewed, encourages the question. At least one study (Das, 1969) suggests that GSR frequency and magnitude may differentiate processing of simple sensory stimuli from the processing of more complex verbal stimuli. Also, Bernstein et al (1975) have demonstrated that the incrementing of verbally induced significance results in a concomitant incrementing of skin conductance response. Current models of attention (Treisman, 1969) may also be summoned to give indirect encouragement to the notion that GSR characteristics may reflect different levels of information processing. An important feature of the Treisman's model is that, the processes of attention are seen as regulating the analysis performed on stimulus input.

The evidence suggests then, that different characteristics of the GSR may be a function of higher forms of cortical-subcortical

integration. As such, it is nonproductive to conceptualize the GSR as a single diffuse reaction to novelty. A better representation would be to conceive the GSR as a constellation of separate, though perhaps interrelated responses, which may be distinguishable by their unique relationships to specific stimulus characteristics. Too often in the past, researchers have restricted their reports to only one or at best two GSR characteristics. This situation has changed significantly in recent years. Increasingly, a variety of GSR indices are being employed to assess the complexity of subject-environment interaction. Edelberg (1970 and 1972) has adopted this approach to the study of GSR during cognitive activity. From this approach, he discovered that some GSR characteristics differentiate certain psychological processes better than others. For example, he found that the GSR recovery rate measure was able to discriminate degrees of goal orientation, when skin conductance level, frequency, and amplitude failed to do so.

Since the present study examined the relationship between GSR and the motivational significance of stimuli, a variety of GSR characteristics were analyzed in an attempt to differentiate between incidental and intentional learning. Continuing on the subject of GSR-motivational relationships, Berlyne, Craw, Salapatek, and Lewis (1963), demonstrated that complex interactions between cognitive and motivational variables may be reflected in the GSR. Their findings showed that the frequency of GSR's to complex or incongruous visual patterns increased significantly only when subjects were "extrinsically motivated". That is, when they were warned that they

would be tested later on their ability to recognize these stimuli.

In concluding this section, it is difficult to resist the temptation to speculate on one more GSR-information processing relationship. That is, the empirically illustrated relationship between arousal and memory consolidation. As will be argued later, this relationship may have some implications for the levels of processing model. A number of studies (e.g., Kleinsmith and Kaplan, 1964; Corteen, 1969; and McLean, 1969) have all reported that GSR-related arousal observed at the time of learning, facilitates memory trace formation. The perseverative hypothesis has been invoked to account for this finding. It may be speculated that levels of arousal may be partially responsible for the pattern of retention obtained from the levels of processing model. The three basic types of questions used to induce differential levels of stimulus analysis in the model, may also concurrently induce different levels of arousal. This may be the case, since attention may vary as a function of the levels of information processing and decision making requirements. Thusly, the semantic orienting questions may elicit higher arousal states than either the physical or phonemic orienting questions. Therefore, it is not inconceivable that the state of CNS activation preceding and during processing of the imperative word-stimulus may be an influential factor in determining the differential retention observed for physical, phonemic, and semantic conditions.

CHAPTER III

RATIONALE, DESIGN, AND HYPOTHESES

Rationale

The preceding literature review has pointed out the potential utility of the levels of processing model in reinterpreting existing data and in providing a new orientation in memory research. However, so far, relatively little research effort has been directed at major tests of the model. It has also been pointed out, that the two major independent tests of the levels of processing model have yielded conflicting evidence regarding the basic tenet of the model, i.e., "depth" and "spread" of processing. On these grounds alone further research on the model is warranted. However, the specific concern of the study is with the depth issue. As was evidenced in the review, this concept still remains the major unresolved problem. What appears to be needed is some independent index of depth of processing. The argument advanced, based on current available evidence, advocated physiological measures as prime candidates for indexing depth.

The above argument was derived from the theoretical and empirical research reviewed. First, the levels of processing model argued that shallow sensory analyses are carried out relatively

easily and require very little attention. On the other hand, deeper cognitive analyses progressively require attention for their successful completion. The model also implies that processing proceeds to the "target" domain or level induced by the orienting task. Secondly, the psychophysiological literature argue for a strong and complex relationship between the attentional value of stimuli and autonomic response pattern. For example, the heart rate literature showed that in a warned reaction time paradigm, the signal stimulus entails information processing and decision making activity; and further, that the amount of heart rate acceleration during the fore-period varies as a function of the stimulus significance. It has also been shown that the magnitude of cardiac deceleration in the fore-period, is also related to the requirements associated with the detection of and processing of the imperative stimulus. It was also argued that increasing the motivational value of stimuli, concomitantly leads to a corresponding increment in the GSR magnitude. It was also further argued on both theoretical and empirical grounds, that the employment of a variety of GSR response characteristics in cognitive research is productive.

The rationale for the present study was based on the evidence and arguments outlined above. It was proposed that: the three levels of orienting tasks used in the present study to induce different levels of processing, reflect different degrees of stimulus significance in terms of information processing requirement associated with the anticipated imperative word-stimulus. One may speculate that this may take the form of generating a pool of

potential answers to the orienting questions, or priming or tuning of a specific domain for subsequent processing. If this is the case, then heart rate acceleration in the fore-period should be consistently related to levels of processing. It was argued that heart rate deceleration reflects preparatory activity, which is related to decision-making requirements associated with the imperative word-stimulus. If this is so, then heart rate deceleration should vary as a function of the amount of anticipated processing which the imperative stimulus must be subjected to before a decision can be made. Similarly, it was proposed that GSR characteristics should be related to levels of processing and decision-making requirements. More specifically, these relationships should be manifested in GSR's associated with both question presentation, and the actual processing of the imperative word-stimulus. It was further proposed that some GSR measures will be more powerful discriminators of levels of processing than others.

Design

The two groups examined in this study were "Incidental Recall" and "Intentional Recall" groups. The only difference between these two groups was that the intentional group was informed at the beginning of the experimental session, that they would be required to recall the imperative word-stimuli, whereas, the incidental group was given an unexpected recall test on the same list of words.

In the present study, a trial continuum consisted of the 20

seconds immediately following the onset of the orienting question. The sequence of events in a trial continuum was as follows: on each trial an orienting question was presented to the subject for four seconds. Six seconds after the offset of this question, an imperative word-stimulus was exposed for 300 milliseconds. The subject's "yes" or "no" button-press response to this stimulus stopped a digital reaction time clock. The fore-period was defined as the ten seconds immediately preceding the onset of the imperative stimulus; and the intertrial interval (ITI) ranged from 20 to 30 seconds, with a mean of 25 seconds.

Each subject in the experiment received the same 30 words in the same sequence, but four different question formats were constructed, which randomly varied the presentation order of question types (physical, phonemic, and semantic) and response types (yes and no) within the block of 30 trials (see Appendix 1.2 to 1.5). For the first 36 subjects, six subjects from each group were randomly assigned to one of the first three question formats, of the remaining ten subjects, five from each group were assigned to the fourth question format.

Three types of orienting questions were employed in the experiment. The purpose of each type of orienting question was to induce the subject to process the imperative word-stimulus to one of three "target" levels of analysis. To induce "shallow" processing of the imperative stimulus i.e., processing at the sensory level, the subject was questioned about the physical structure of the word,

e.g., "Is the word in capital letters?" To elicit an "intermediate" level or phonemic processing, questions about the rhyming characteristics of the word were asked, e.g., "Does the word rhyme with Each?" To induce relatively "deep" or semantic processing of the word-stimulus, questions related to categories were asked, e.g., "Is the word a type of material?"

Hypotheses

The hypotheses concerning recall and decision latency were tested in an attempt to confirm previous findings of Craik and Tulving (1975). The hypotheses regarding HR and GSR measures are new hypotheses and were tested to evaluate the relationships between autonomic responses and levels of processing and incidental-intentional learning distinction.

The rationale for these hypotheses may become clearer if it is recognized that qualitatively different types of mental activities may be operative during different intervals of the trial continuum. For example, it may be suggested that in both incidental and intentional trials the following sequence of psychological processes may be operative. In the initial six seconds the orienting questions probably activate priming of a specific domain or a semantic or phonemic matrix. This is followed in the four seconds prior to imperative stimulus onset by preparatory activity, and then by a brief subsequent processing of the imperative stimulus. Additionally,

it is expected that rehearsal activity will take place in the post-response interval of the trial continuum in the intentional learning condition. This pattern of psychological processes in the trial continuum should be reflected in the autonomic response changes predicted by the following hypotheses.

Performance

Hypotheses 1. The intentional learning group will display higher recall performance than the incidental group. This prediction was advanced because it was previously argued that intention to remember probably represents an encoding operation over and above that induced by the different types of orienting tasks in the incidental condition.

Hypothesis 1.1. In both intentional and incidental learning groups, recall performance will be positively related to depth of processing. The rationale for this hypothesis is based on the crucial assumption of the levels of processing model, which states that it is the nature of the encoding operation more than any other factor which determines retention performance.

Hypothesis 1.2. There will be greater recall of words given a "yes" response than words given a "no" response. Craik and Tulving (1975) suggested that words associated with a positive response should be better retained than words associated with a negative response for the following reason. Words given a "yes" response form an integrated unit with the orienting question, thus leading to a more elaborate or distinctive memory trace than words given a "no" response.

Hypothesis 1.3. Response latency will be positively related to depth of processing. This hypothesis was based on the rationale that given a class of stimuli or a specific stimulus, deeper processing is assumed to require more time.

Heart rate

Hypothesis 2. The intentional learning group will display higher second-by-second heart rate throughout the trial continuum than the incidental learning group. It was expected that an increase in motivational level in the intentional condition combined with increased mental activity (rehearsal) in this condition will result in elevation of HR over and above that for the incidental condition.

Hypothesis 2.1. The intentional learning group will display both greater heart rate acceleration and deceleration in the fore-period than the incidental learning group. According to the two-component hypothesis of HR change (Coles and Duncan-Johnson, 1975) both HR acceleration and deceleration in the fore-period of a reaction time task vary as a function of stimulus significance. It was expected that knowledge of a subsequent memory test in the intentional condition would result in incrementing of the significance of both the orienting question and the imperative stimulus. In the incidental condition the orienting question evokes the decision that a future stimulus must be processed to one of three target domains. In the intentional condition the orienting question has the additional property of signalling that the imperative stimulus must also be stored.

Hypothesis 2.2. In both intentional and incidental learning groups, heart rate acceleration and deceleration in the fore-period will be positively related to levels of processing. Previous researchers (Lacey, 1970; Coles et al, 1975) have shown that HR acceleration in the fore-period of a reaction time task is positively related to the information value of the warning signal. In the present study it was assumed that the different types of orienting questions reflect different degrees of stimulus significance in terms of the processing requirements associated with the anticipated imperative stimulus. The three types of questions also probably elicit different degrees of anticipatory cognitive activity. Extensive research in a variety of learning situations has shown a systematic relationship between HR deceleration and decision making requirements associated with the imperative stimulus.

Hypothesis 2.3. Heart rate acceleration in the post response interval will be greater in the intentional than in the incidental group. This prediction was advanced on the assumption that subjects in the intentional condition will rehearse the imperative word-stimuli in the post-response interval. Lacey et al (1967) and Tursky et al (1970) have reported HR acceleration to covert rehearsal.

Galvanic Skin Response

Hypothesis 3. The magnitude of the GSR to both the orienting question and the imperative word-stimulus will be greater for the intentional than for the incidental learning group. As was stated earlier, a number of studies (e.g., Berlyne et al, 1963) have demonstrated a

positive relationship between motivational level and GSR magnitude.

Hypothesis 3.1. In both intentional and incidental learning groups, GSR magnitude will be positively related to levels of processing. It has been demonstrated that increasing of stimulus significance (Bernstein et al, 1975) and the increasing of cognitive demand (Tursky et al, 1970) result in a concomitant increase in GSR magnitude.

Hypothesis 3.2. GSR frequency will be greater in the intentional than in the incidental learning group. Like GSR magnitude, it was found (Berlyne et al, 1963) that instruction to remember results in an increase in GSR frequency.

Hypothesis 3.3. In both intentional and incidental learning groups, GSR frequency will be positively related to levels of processing. Das (1969) suggests that GSR magnitude and frequency may differentiate simple sensory processing from the processing of complex verbal stimuli.

Hypothesis 3.4. GSR recovery rates will be faster in the intentional than in the incidental learning groups. Edelberg (1972) has demonstrated that electrodermal recovery rate varies as a function of activation level. It was suggested that knowledge of a subsequent memory test would serve to increase general activation level in the intentional condition over and above that for the incidental condition.

Hypothesis 3.5. In both intentional and incidental learning groups, GSR recovery rates will be positively related to levels of processing. Edelberg (1972) has also suggested that fast GSR recovery rates may be positively related to the degree of goal-directed behavior. In the present experiment goal-directed behavior is decision-making. The

implication is that recovery rate should vary as a function of decision-making requirements.

Since the functional significance of GSR latency in information processing is still nebulous, no specific predictions were made regarding this measure in the present study. Consequently, examination of this measure in the present study may be considered as exploratory.

CHAPTER IV

METHOD

Subjects

Forty-six male volunteers enrolled in undergraduate educational psychology courses served as subjects. Their mean age was 21.7 years, range 18.0 to 30.0 years. All subjects were right-handed and reported no sensory or motor impairments.

Two subjects were excluded from the heart rate statistical analyses; one, because of excessive artifacts in the heart rate polygraph records, and the other was randomly discarded in order to retain equal N's for ease of analysis. Excessive artifacts comprised of those scores which were 20 or more points greater than or less than the prestimulus level. For the GSR analyses another four subjects were excluded; two, because of negligible responding (less than six GSR's in 30 trials), the other two were randomly discarded to achieve equal N's. Thus, for the above analyses, the final samples were comprised of 22 and 20 subjects respectively.

Apparatus

A Hewlett-Packard model 1500 polygraph with an integrated

cardiotachometer was used to obtain continuous recordings of each subject's heart rate and galvanic skin responses. Three channels were used as follows: (1) to measure heart rate change, (2) to record galvanic skin responses, (3) to record the sequential onset of events in a trial continuum. The polygraph paper ran at a constant speed of 5mm/second.

Heart rate measures were recorded by the use of silver-silver chloride electrodes 0.5 inches in diameter, placed on the sternum and the left third rib, and a neutral ground on the right elbow. Galvanic skin responses were recorded by means of three silver-silver chloride electrodes 0.5 inches in diameter. One was attached to the left palm, one to the back of the left hand, and a ground electrode was placed near the left elbow approximately ten inches from the wrist. The right hand was left free for response execution. The electrodes were filled with Beckman sodium chloride electrode paste (0.5 concentration) and were secured to the recording sites by adhesive collars. Recording sites were cleaned with rubbing alcohol prior to electrode application.

The sequence of onset and duration of experimental stimuli in a trial continuum were automatically controlled by Hunter Decade Interval Timers. A kodak carousel slide projector, mounted with an electro-mechanical shutter was used to control stimulus exposure time. An electronic luminous digital display stop clock (Southwest Instruments Corporation) was used to measure reaction time. The clock was started by a Hunter Timer which activated the shutter and

it was stopped by the subject's button-press response. This button-press response also simultaneously lit up one of two lights ("yes" or "no") indicating the subject's decision. The response apparatus consisted of two push buttons protruding from a metal box strapped to the arm rest of the chair by a broad elastic band. This response box was adjusted for each individual subject to ensure maximum efficiency in responding. The stimuli were projected at eye level through a one-way mirror on to a screen located four feet directly in front of the subject. In addition to physiological signals, stimuli onsets and button-press responses were recorded on the polygraph paper. All recording and control apparati were housed in a room adjacent to the experimental chamber.

Stimulus Materials

The experimental task involved the use of slide-mounted orienting questions and related imperative word stimuli. Thus, it may be suggested that these stimuli were associated with more complex cognitive activity than the traditionally used sensory stimuli in autonomic research. The 30 orienting questions and words used in this experiment consisted of a random sample selected from the report of Craik and Tulving (1975). The word stimuli were common nouns of four to seven letters in length.

Procedure

All subjects were tested in an electrically shielded sound-

proof room with temperature controlled at 70^{0}F. Each subject was randomly assigned to one of the two groups as he arrived for the experiment. After the subject was seated in a semi-reclining position in a padded armchair, the experimenter informed him that the experiment was concerned with perception and speed of reaction time. Subjects in the intentional group were additionally told that the memory task was of equal importance to the reaction time task and that they should attempt to remember as many words as they could. The formal instructions were then given: subjects were told that on each trial a question will be presented on a screen for a few seconds which will be succeeded after a few seconds by a brief presentation of the stimulus word. They were instructed to respond to the word by pressing the appropriate response button. Each subject was further encouraged to respond as quickly as possible but also to avoid making errors. The subject's response and his response latency were recorded immediately after response execution. Then the experimenter advanced the slide projector to the next question in preparation for a new trial. The word-slide was advanced during the six-second interstimulus interval by the experimenter.

Six practice trials, one of each of the six types of trials (3 question types x 2 response types) were administered prior to the actual experimental trials. At the end of the 30 trials each subject was given a one minute rest and was allowed up to five minutes for free written recall. At the end of this recall interval, subjects were interviewed and asked not to inform future subjects that a memory task was part of the experiment. Subjects were alone in the

experimental chamber but could be observed through a one-way viewing window.

Scoring

The polygraph records were scored manually.

Heart Rate

Second-by-second heart rate change.

Figure 1a shows an actual polygraph output of second-by-second HR change in a trial continuum. For each subject, 22 second-by-second heart rate values were obtained for each of the 30 trials. These values consisted of a continuous sample of heart rate beginning two seconds immediately prior to the question onset and ending ten seconds after the word slide onset. The second-by-second beats per minute (BPM) change scores were calculated by taking the difference between the mean BPM for the two seconds prior to onset of the orienting question and the twenty 1-second intervals following orienting question onset.

Galvanic skin response measures.

Magnitude.

A skin conductance response was a pen deflection which began

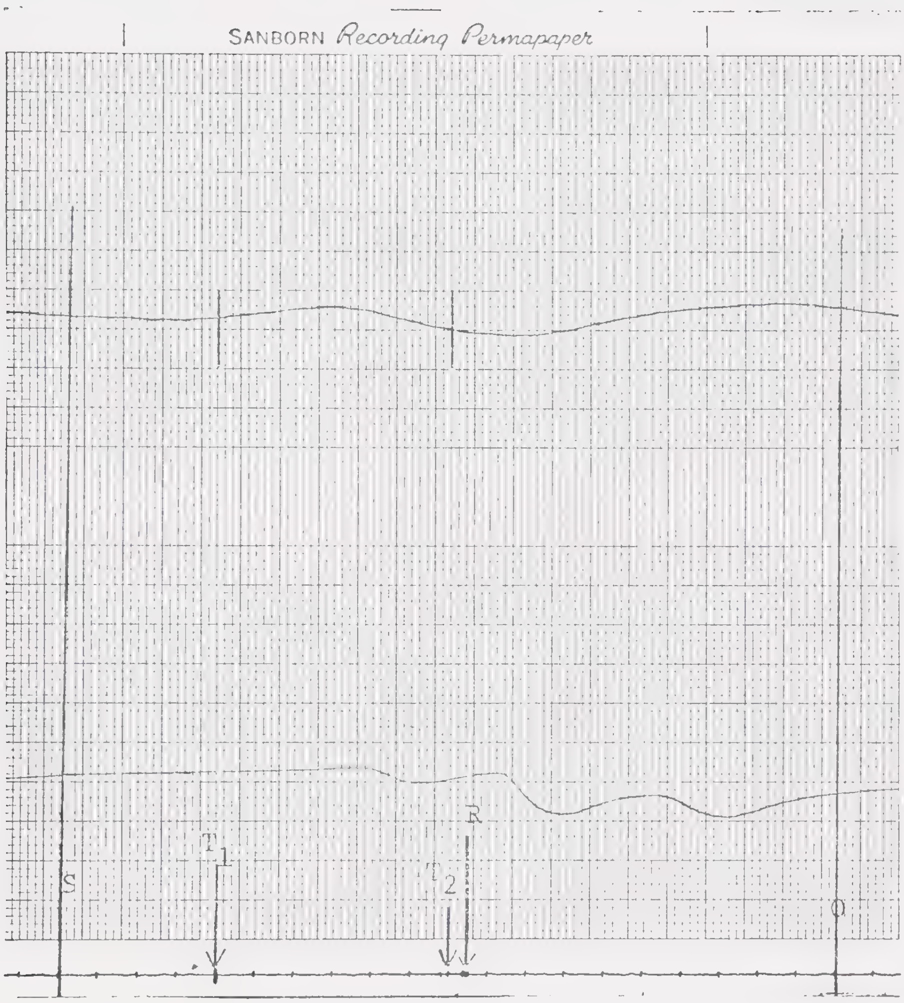


FIGURE 1a. Polygraph output of second-by-second HR change (top) and GSR change (bottom). (Distance between consecutive points represents 1-second intervals. Points marked S, T , T , R, and O indicate trial onset, orienting question offset, imperative stimulus onset, response and end of trial continuum respectively).

within one to five seconds after the onset of the orienting question or the imperative word stimulus. The pre-stimulus values for this measure were obtained by calculating the mean conductance for the two 1-second intervals immediately preceding the orienting question.

Frequency.

This measure consisted of the number of scorable galvanic skin responses equal to or exceeding 500 ohms which occurred within one to five seconds after the orienting question or the imperative stimulus word.

Latency.

This measure was obtained by recording the elapsed time between the start of a response and maximum polygraph pen deflection associated with the imperative word stimulus.

Recovery.

This was obtained by recording the elapsed time between maximum polygraph pen deflection and the point of 50% recovery to baseline, associated with the imperative word-stimulus.

Scoring Accuracy.

The scoring reliability was assessed by having another individual

score independently five trials for each measure for ten randomly selected subjects. Of 1100 heart rate values scored, disagreements of more than two beats per minute occurred on 3.73% of the measurements. For galvanic skin response magnitude, scorers disagreed on 6% of responses scored by 500 ohms or greater. Finally, disagreements of 0.0%, 3%, and 4% occurred for frequency, latency, and recovery respectively.

Rationale for autonomic response measures.

Heart Rate.

Graham and Jackson (1970) in an extensive review of the related literature, advocated the use of unadjusted difference scores when the experimenter's interest lies only in the direction of heart rate change. With respect to the use of second-by-second heart rate change scores, Graham and Clifton (1966) and Graham and Jackson (1970) have pointed out in literature reviews and have shown from their own research findings that this measure provides a reliable and meaningful index of the relationship between cardiac activity and experimental variables. Concerning peak-to-trough deceleration, a number of authors (e.g., Johnson and May, 1969; Bower, 1976; Coles and Duncan-Johnson, 1975) have discovered that this measure provides a reliable index of heart rate deceleration during the fore-period of a reaction time task.

Galvanic Skin Response.

As was pointed out before, too often researchers' reports are restricted to only one GSR measure - usually amplitude or magnitude. However, the new emerging conceptual model of the GSR (e.g., Maltzman, 1968; Prokasy and Kumpfer, 1973; and Bernstein, Taylor, and Weinstein, 1975) as a multi-faceted response, differentiating mediational processes, dictates that a variety of GSR characteristics be examined. In this study, multiple GSR characteristics were analysed with the hope of identifying meaningful relationships between them and specific manipulations of information processing and decision-making requirements. Also, regarding the preference for GSR magnitude over the amplitude measure, it has been shown (e.g., Lobb, 1970) that the former is a more sensitive measure, since the latter is considerably affected by missing scores.

CHAPTER V

DECISION LATENCY AND RECALL: RESULTS AND DISCUSSION

Decision Latency: Results.

The results for response latency show that in general, deeper levels of processing are associated with longer latencies (see Table 1). These results are consistent with the data obtained from other research on levels of processing, employing a reaction time paradigm (Craik and Tulving, 1975: Experiments 1 - 4). The median latency for each level and response type for each subject was calculated. The values in Table 1 are the means of medians.

The median latency scores were subjected to an analysis of variance. A significant main effect for levels $F(2,84)=72.58, p<.001$ was obtained. There was no main effect for learning conditions (incidental/intentional), nor for response types (yes/no) (see Appendix 2.1), but there was a significant levels x response type interaction; $F(2,84)=4.023, p<.05$. This interaction is graphically depicted in Figure 1, and shows that whereas at the phonemic and semantic levels, decision latencies associated with positive responses exceed those associated with 'no' responses, the opposite trend is evident for the corresponding latencies associated with the physical

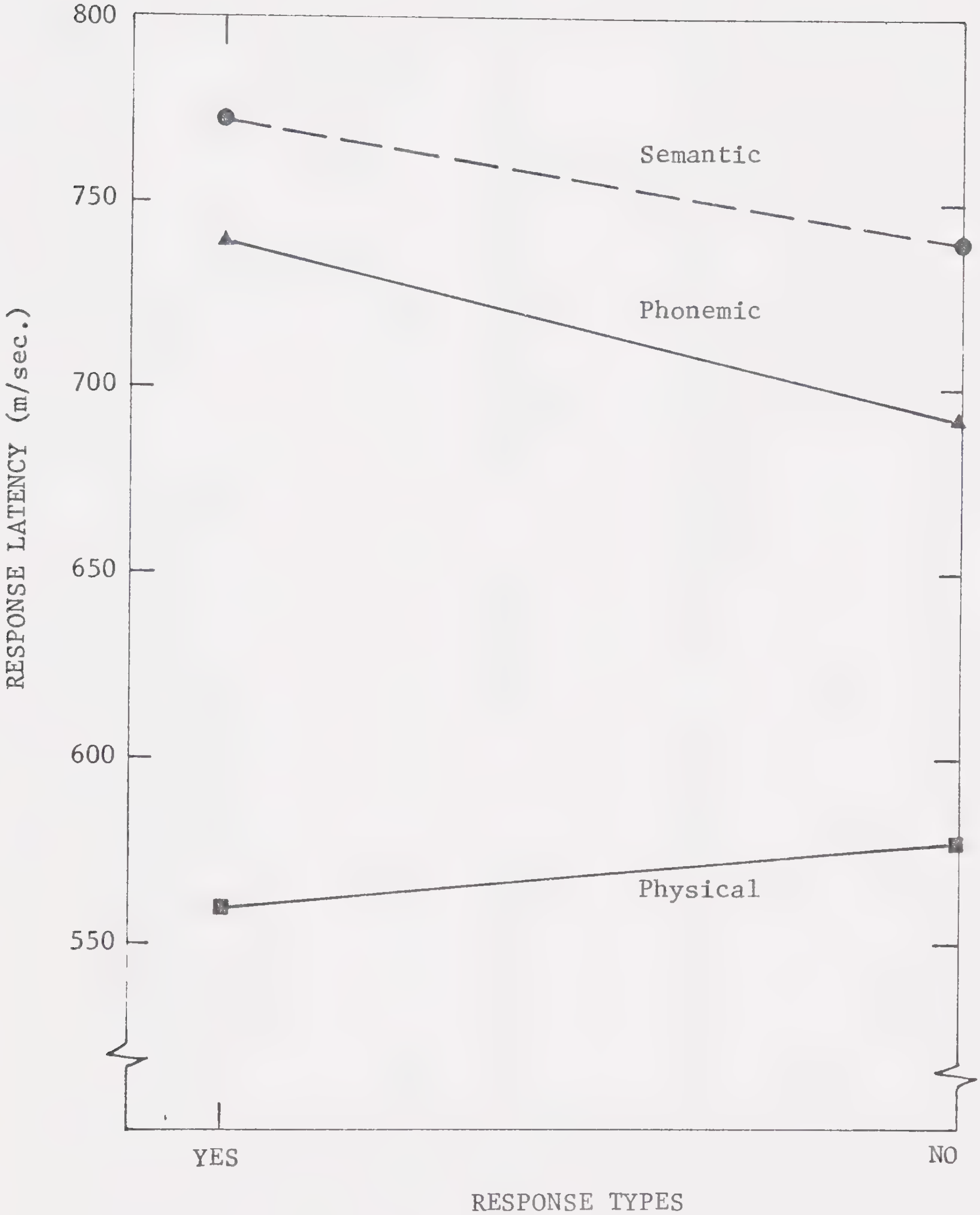


FIGURE 1. Decision Latency (Collapsed Over Learning Conditions) as a Function of Levels x Response Type Interaction.

TABLE 1

Decision latency in milliseconds for correct responses as a function of levels of processing for incidental and intentional conditions.

	INCIDENTAL			INTENTIONAL		
Response	Physical	Phonemic	Semantic	Physical	Phonemic	Semantic
Yes	538	696	780	589	785	774
No	575	673	708	588	715	774

level.

In order to determine the degree of the differences between response latencies associated with each of the three levels of processing, separate Schéffe tests (see Winer, 1973) of individual comparisons between means were conducted on yes and no response latencies respectively. The results of these tests are shown in Appendix 2.2. An inspection of these results reveals that both phonemic and semantic response latencies exceeded physical response latencies. However, there was no difference in response latencies between phonemic and semantic levels. Schéffe multiple comparison of the mean response latencies averaged over response type (yes/no) in each of the two learning conditions (incidental/intentional), revealed the same pattern of results. These results are somewhat inconsistent with those obtained by Craik and Tulving (1975). They had shown a systematic increase in response latency from physical through phonemic to semantic levels of processing.

Decision Latency: Discussion.

The decision latency results gave qualified support to the predictions of the levels of processing model. The notion that time to make decisions may serve to dichotomize shallow level processing from deeper level processing is supported. This support comes from the finding that both phonemic and semantic encoding take longer than physical encoding, but there was no difference between

phonemic and semantic encoding times. However, the evidence does not support any further detailed differentiation beyond this general dichotomy. Thus, it may be argued on the basis of the present results, that reaction time may not be a reliable index for differentiating levels of processing deeper than physical analysis.

The limitations of decision latency as an independent index of depth or elaboration of processing, is further emphasized by the reaction time results related to both the incidental-intentional, and response type manipulations. These results show that neither knowledge of the final recall test, nor response type had any effect on the subjects' decision latencies. If decision times were to vary directly with the depth of processing, then this finding is contradictory to the theoretical notion outlined previously, which stated that both intentional learning condition and positive response type are associated with elaborative encoding. This notion implies that decision times should bear some relationship to the experimental manipulations of learning conditions and response type. However, as the results show, there was no such effect.

Alternatively, it may be argued that processing of a stimulus at deeper levels does not end with a judgment. This line of argument is consistent with Meyer's (1970) theoretical and empirical analysis of true/false reaction times to certain specific propositions. Meyer concludes that such decisions involve wither one stage or two stages of processing. From his proposals, one gathers that information processing does not end with a match-mismatch decision; but proceeds

to a more elaborate confirmatory stage. The above argument implies that additional processing is more characteristic of congruent than incongruent decisions. The preceding argument focusses on the relationship between post decision processing and congruent-incongruent judgments. This argument may also be extended to include the suggestion that such factors as type of orienting task and learning condition may also influence not only the quality of pre- but also post-decision processing. Hence there is a difference in retention between yes and no response types, and incidental and intentional learning conditions, but no such corresponding difference exists in decision time, as was evidenced in the present study. In other words, although response latency may reflect an initial amount of processing which is pre-requisite for a judgment, it does not index eventual depth of processing.

Recall: Results.

The recall scores for both incidental and intentional learning conditions are presented in Table 2. Scores are expressed as percent correct recall. It should be noted that the overall performance in both conditions is markedly higher than those reported by other authors (e.g., Schulman, 1974; Craik and Tulving, 1975; and Lawson, 1976). As can be seen, the pa-tern of recall results is quite consistent with the predictions of the levels processing model. Recall performance in both conditions increased with levels of processing. Analysis of variance of the percentage scores yielded

TABLE 2

Percentage correct recall as a function of levels of processing for incidental and intentional groups.

	INCIDENTAL			INTENTIONAL		
Response	Physical	Phonemic	Semantic	Physical	Phonemic	Semantic
Yes	12.73	27.27	59.10	34.55	45.46	63.64
No	6.36	10.91	31.82	28.18	37.27	49.10

a highly significant main effect for levels; $F(2,84)=74.40, p<.001$. One of the major issues raised by the Lawson (1976) study was that of the lack of distinctiveness in recall performance between the postulated three qualitatively different levels of processing. His study did not provide evidence which clearly and consistently differentiated these three levels in terms of recall performance. In order to evaluate the degree of distinctiveness in recall performance between these three levels of processing, the data was subjected to a Schéffe multiple comparison of means analysis. An examination of Figure 2 and the probability matrices in Table 3 reveals a significant distinction in recall performance between the three levels (semantic>phonemic>physical) in the incidental learning condition. However, in the intentional learning condition, while there was a clear statistical distinction in recall between physical and semantic; and phonemic and semantic levels, there was no such difference in recall between the physical and phonemic levels of processing.

With regard to learning conditions, Figure 2 indicates that recall under the intentional learning condition was superior to recall under the incidental condition at all levels. An analysis of variance shows that the main effect for learning conditions was significant; $F(1,42)=20.40, p<.001$. However, although an individual comparison of means (see Appendix 2.3) between groups at each of the three levels yielded significant differences, an examination of the actual percentage differences indicates that both physical and phonemic levels of processing clearly benefitted more from

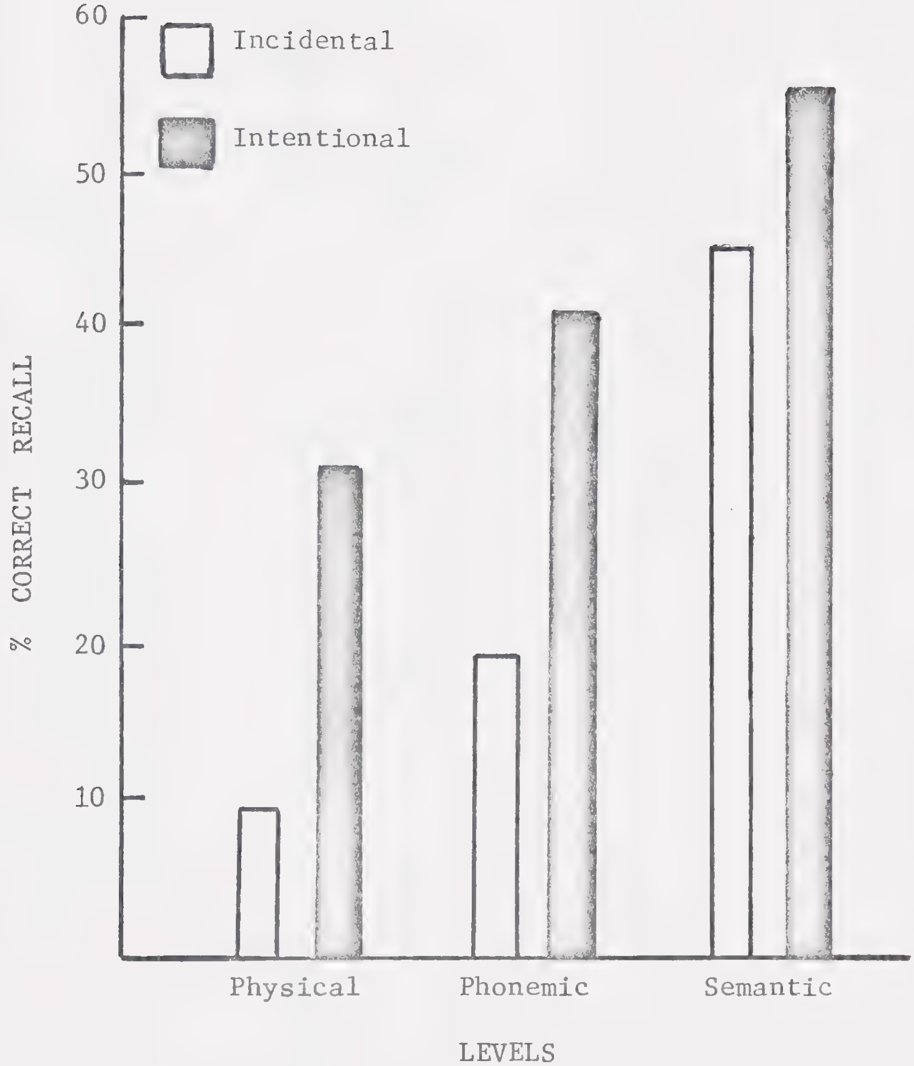


FIGURE 2. Diagram of Levels x Condition Interaction.

TABLE 3

Probability matrix for Schéffe multiple comparison of recall means for incidental and intentional conditions collapsed over response types.

INCIDENTAL				INTENTIONAL			
Means Levels	9.5 Phys.	19.1 Phon.	45.5 Sem.	Means Levels	31.4 Phys.	41.4 Phon.	56.4 Sem.
Phys.	____	0.04	0.0	Phys.	____	.26	0.0005
Phon.		____	0.0	Phon.		____	0.05

instructions to recall, than the semantic level. The percentage increase in recall from the incidental learning condition to the intentional condition at each level were; 21.82%, 22.73%, and 10.91% for physical, phonemic, and semantic levels respectively.

The results of recall performance relating to response type are illustrated in Figure 3. The pattern of recall performance is quite similar to that obtained by Craik and Tulving (1975). An analysis of variance of these data yielded a significant main effect for response type; $F(1,42)=28.34, p<.001$. In both learning conditions, mean recall of words associated with a positive response was clearly superior to mean recall or words associated with a negative response. However, individual comparisons of yes-no recall means (see Appendix 2.4 and 2.5) revealed that these yes-no differences were restricted only to the phonemic and semantic levels.

Recall: Discussion.

In general, the pattern of recall results obtained in the present study provides strong support for the levels of processing model. The experimental results support the notion that it is the nature of the encoding operations performed on the stimulus items, more than anything else, which determines recall performance. Other recent investigations (Schulman, 1974; Craik and Tulving, 1975; and Lawson, 1976) have reported very low levels of recall under incidental conditions, especially in the physical and phonemic

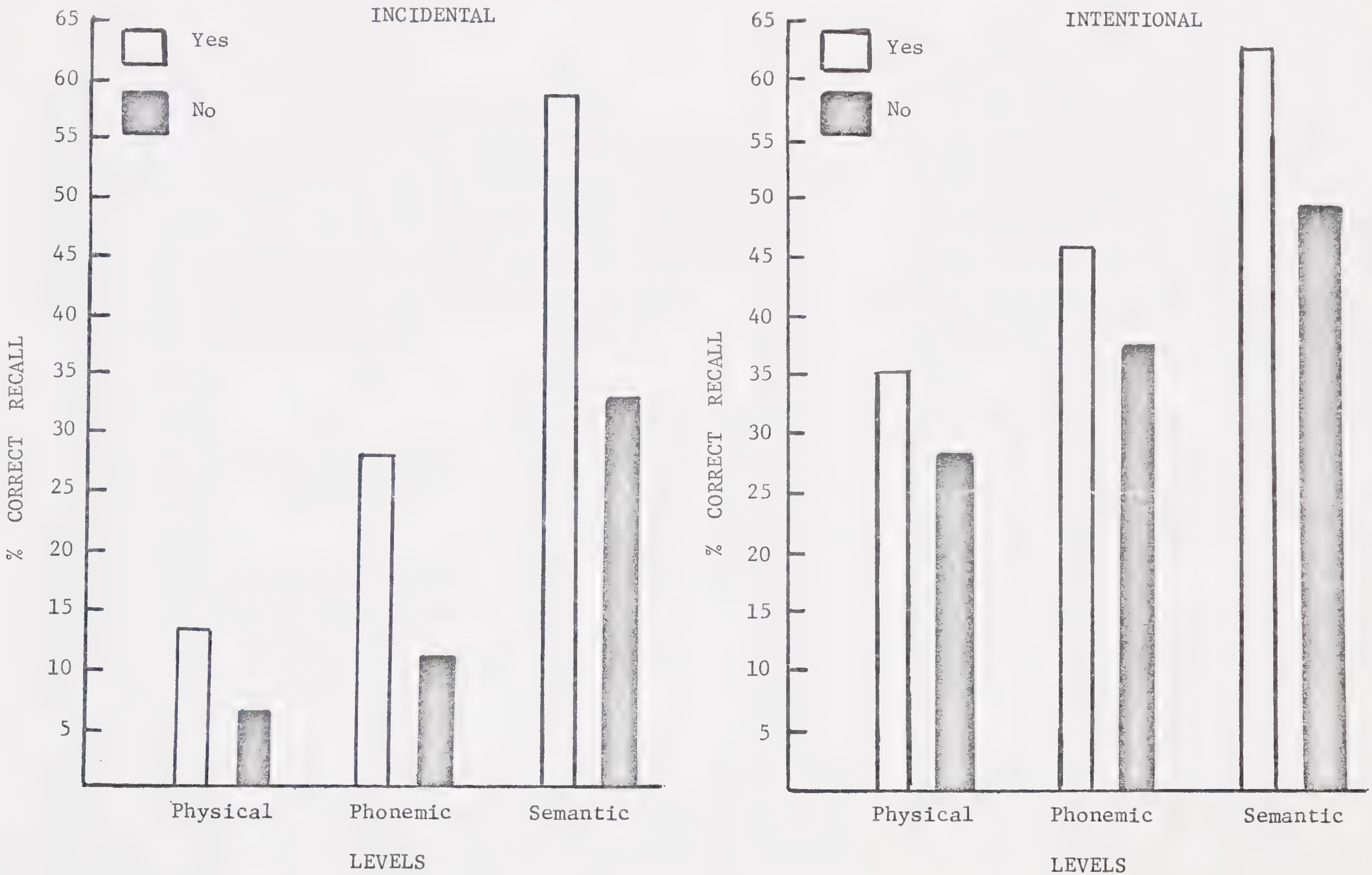


FIGURE 3. Diagram of Levels x Response Type Interaction.

categories. These findings have led at least one author (Lawson, 1976) to conclude that the free recall task may not provide a sufficiently sensitive measure for differentiating between the physical and phonemic levels of processing.

However, it has been demonstrated by the present results, that the free recall procedure can provide adequate differentiation of the three qualitatively distinct levels of processing. The data show that levels of recall in the incidental and intentional learning conditions were sufficiently high to provide a clear statistical separation of these three hierarchically arranged levels of analysis. Orienting questions which induced semantic analysis yielded higher levels of retention than questions inducing either phonemic or physical analyses; and questions concerning the stimulus-word phonemic characteristic in turn, yielded higher recall than questions about purely physical characteristics.

Some of the methodological differences between the present study and the recent studies mentioned above may have accounted for the differences in the levels of recall performance. First, there was a difference in list length. Previous studies used list lengths of at least 60 words, whereas, the present study used a 30-word list. The learning of short lists may be more advantageous for free recall than the learning of long lists. This notion is supported by research (e.g., Murdock, 1962; Shiffrin, 1970; Waugh, 1967 and 1972), which indicates that the number of items recalled increases as a negatively accelerated function of list length. Secondly, both the

inter-stimulus interval (ISI) and the inter-trial interval (ITI) were substantially longer in the present study than in previous studies. Speculatively, long ISI might have encouraged more comprehensive activation of the phonemic or semantic matrix in which the target word is embedded. This might have given rise to the formation of more elaborate associations which facilitated retrieval. Also, longer ITI might have been conducive to elaborate post-decision processing. Finally, level of arousal cannot be discounted as a possible influential factor. It is likely that electrode attachments, and the recording of physiological responses may have had an incrementing effect on arousal over and above that produced in the other studies. The well-known effects of arousal on recall performance have been previously documented.

The results of the present study confirm previous findings of superior recall for intentional learning over incidental learning (Craik and Tulving, 1975; Lawson, 1976). Examination of the results (Figure 2) yields support for the proposal that instructions to learn have a greater facilitatory impact on retention, especially at the physical and phonemic levels. This is substantiated by the finding that the increase in recall from the incidental learning condition to the intentional learning condition for both the physical and phonemic levels, is twice the corresponding increment for the semantic level. These findings are consistent with the results of previous studies (Jacoby and Goolkasian, 1973; Lawson, 1976).

It may be suggested, on the basis of the above evidence, and

in agreement with Postman (1956 and 1964), that instructions to learn primarily benefits physical and phonemic recall, because it encourages processing in a more effective manner, than the analyses elicited by the orienting task in the incidental learning condition. Instructions to learn might have induced more elaborative lateral and vertical encoding, whereas, the physical and phonemic orienting questions in the incidental learning condition might have restricted processing to a state compatible only with the orienting task. This argument is reinforced by the present findings, which revealed greater inter-level recall differentiation within the incidental learning condition than within the intentional learning condition. Examination of the data also shows that there is greater differentiation in recall performance between yes and no response types within the incidental learning condition, than in the intentional learning condition.

Inequality of retention resulting from incidental-intentional manipulations poses no threat to the notion that; "It is the nature of the encoding operations which is crucial for retention" (Craik and Tulving, 1975. p. 289). As was suggested previously, the intentionality dimension may be conceived as inducing certain specific elaborative encoding operations over and above those induced by questions in the incidental condition. Consequently, although differences in retention between levels within the intentional learning condition will be found, these differences will be substantially reduced as a result of this additional elaborative processing.

It should be noted at this point that the recall data from both learning conditions were examined for obvious manifestations of serial position effects. A graphical illustration of the raw recall frequency of each consecutive word is presented in Appendix 2.8. This information reveals no obvious indication of a primacy or recency effect.

Finally, the finding that words associated with a positive response were better recalled than words associated with a negative response is consistent with several other studies. Examination of the recall scores reveals that positive-negative differences were exclusive to the semantic level in the intentional learning condition; and to the phonemic and semantic levels in the incidental learning condition. This finding is compatible with the notion (Schulman, 1974) that the encoding of words given a positive response is more elaborate, and leads to unique or distinctive traces than the encodings of words given a negative response.

It may be concluded that the recall results from the incidental learning condition (and to a lesser extent, that from the intentional condition) support the proposition of three qualitatively distinct hierarchically arranged levels of analysis as advocated by the levels of processing model of memory.

CHAPTER VI

CARDIAC ACTIVITY AND LEVELS OF PROCESSING: RESULTS AND DISCUSSION

Results.

The major independent variables under consideration in the HR analyses were (i) learning conditions, i.e., the effects of incidental vs intentional learning on HR; and (ii) levels of processing, i.e., the effects of physical, phonemic, and semantic processing on HR. In the data analysis two main characteristics of heart rate change were examined. One was the mean second-by-second HR change during the entire trial continuum. This continuous second-by-second tracking of HR change appears to be more compatible with the longer lasting tonic characteristic of HR rather than with its phasic aspects (c.f. Graham and Clifton, 1966). The importance of examining this measure was pointed out earlier. It is expected that this measure will indicate the HR level associated with manipulations of the independent variables in the entire trial continuum. The other aspect of HR change examined concerns the phasic-like qualities. These include (i) accelerative, (ii) decelerative, HR change.

Accelerative changes were defined as the difference between the

mean prestimulus HR and peak HR between seconds five and eight. Decelerative changes were defined as the difference between the mean prestimulus HR and the lowest beat per minute between seconds 10 and 13. The above measures were expected to reveal the relationships between the independent variables and HR changes in the fore-period. In order to evaluate the effects of intentional vs incidental learning on HR change, comprehensive analyses of variance were carried out involving the data from both of these learning conditions. Additionally, separate within-Ss analyses were performed to determine the differential effect of each of three types of orienting tasks and levels of processing on HR change in each learning condition.

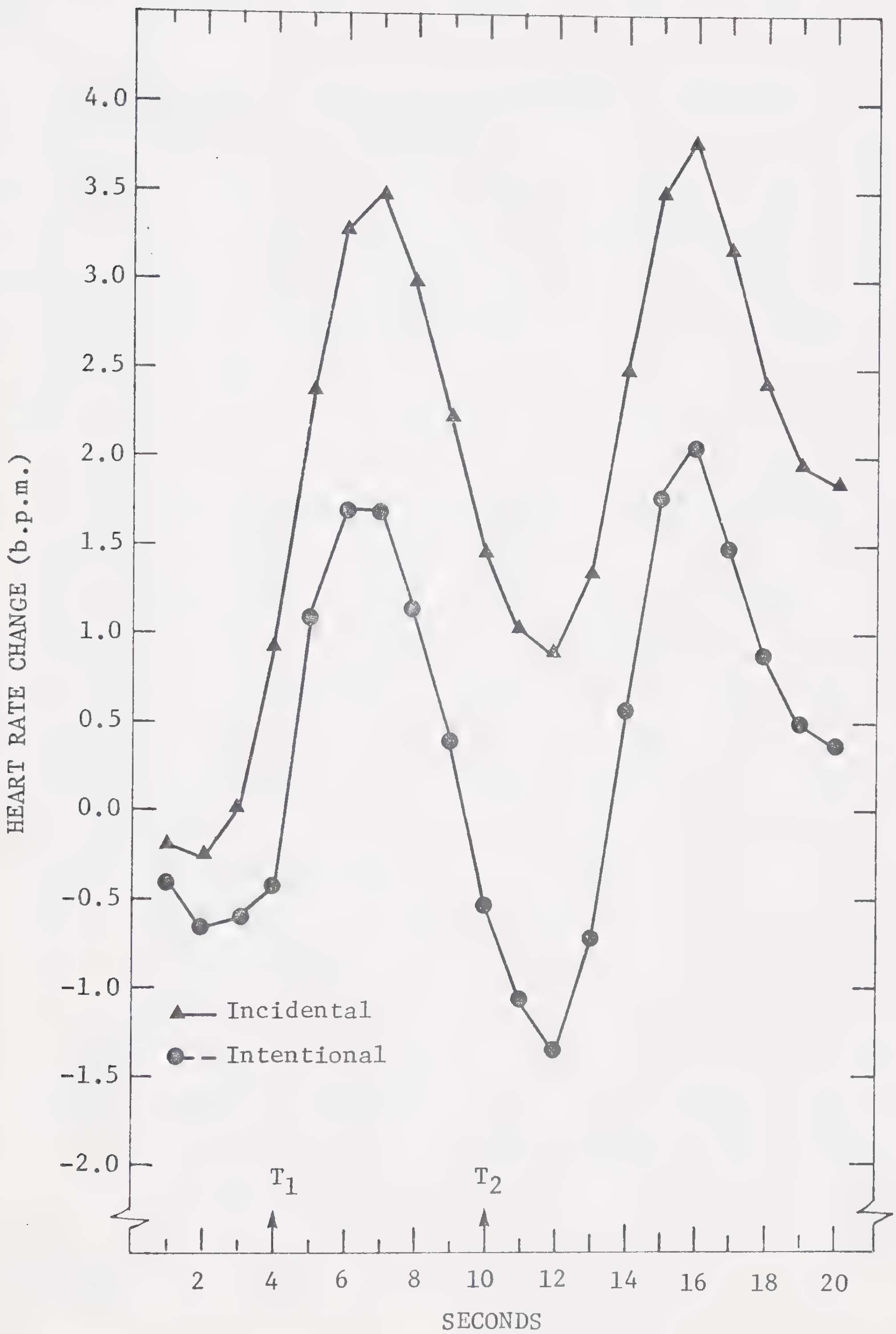
Second-by-second analysis. In all HR data analyses, the data from error trials were excluded. The mean number of errors were quite small: 1.6 and 2.6 for incidental and intentional conditions respectively. Prestimulus HR levels have been known to affect poststimulus HR change (Graham and Jackson, 1970). In order to assess this relationship, an analysis of variance on prestimulus HR values involving 2(groups) x 3(levels) was carried out. The ANOVA revealed no significant effects for groups; $F(1,42)=1.66, p>.10$; nor for levels $F(2,84)=2.50, p>.05$. The prestimulus means were; 69.35 and 73.04 (bpm) for incidental and intentional conditions respectively; and 71.05, 71.17, and 71.37 for physical, phonemic, and semantic levels respectively.

Figure 4 shows the mean second-by-second HR change values averaged over levels for the incidental and intentional conditions.

A clear distinction between incidental and intentional conditions in terms of HR level throughout the trial continuum may be noticed; the curves are almost parallel over the entire trial continuum. The incidental condition clearly exceeds the intentional condition. An analysis of variance involving one between-Ss factor (intentional/incidental learning) and two within-Ss factors (levels and seconds) revealed a highly significant main effect for learning conditions; $F(1,42)=15.96, p<.001$. The ANOVA Table is reported in Appendix 3.2. This finding is the opposite of what was predicted by hypothesis 2, which stated that overall second-by-second HR level in the intentional condition would exceed that for the incidental condition. The main effect for seconds was highly significant; $F(19,798)=33.25, p<.001$, indicating that the second-by-second change from prestimulus level were reliable. The analysis also showed that the seconds-by-group interaction was significant; $F(38,1596)=2.76, p<.001$ and also the levels-by-seconds interaction; $F(38,1596)=2.76, p<.001$. The source of these interactions may become clearer by an inspection of the results of the within-Ss second-by-second analyses which follow shortly.

Figure 4 shows that on the basis of the second-by-second response topography, the two curves may be conveniently divided into five consecutive 4-second intervals. As may be observed, each of these 4-second intervals may be characterized by a predominant HR pattern, each of which may underlie a distinctive psychological process. For example, the predominantly decelerative HR change during seconds 1 to 4 may reflect stimulus intake (Lacey, 1967),

FIGURE 4. Mean second-by-second HR values for the two learning conditions. (Each point represents the difference between the mean of the two prestimulus HR values and the HR values for each second. Points marked T_1 and T_2 indicate offset of orienting question and onset of imperative stimulus respectively).



4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
HEART RATE CHANGE (b.p.m.)
Incidental
Intentional
T_1
T_2
2
4
6
8
10
12
14
16
18
20
SECONDS

whereas the predominantly accelerative HR during seconds 5 to 8 may involve cognitive involvement.

A three-way analysis of variance was carried out on each of these five intervals to determine the extent of the difference between the two conditions at each segment of the curve. The results of this ANOVA presented in Table 4 show that the main effect for groups was uniformly significant at all five segments of the HR curve.

Finally, in order to determine the degree of habituation to the task over the experimental session, the following procedure was adopted: for each subject and for each level of each condition, the total trials were divided into two blocks of early and late trials. An analysis of variance on the resulting data indicated no overall decrease in HR from early to late trials; $F(1,42)=2.79, p>.10$. However, a similar analysis on the prestimulus level data yielded a highly significant main effect for trials; $F(1,42)=14.88, p<.001$. The mean prestimulus HR levels were 72.08 b.p.m. and 70.30 b.p.m. for early and late trials respectively. These results indicate that although there was a marked decrease in arousal level from early to late trials as indexed by HR, attentional involvement in the actual task as indicated by the phasic characteristic of HR remained stable throughout the experimental session.

TABLE 4

ANOVA for the five consecutive 4-second intervals involving 2(conditions) x 3(levels) x 4(seconds).

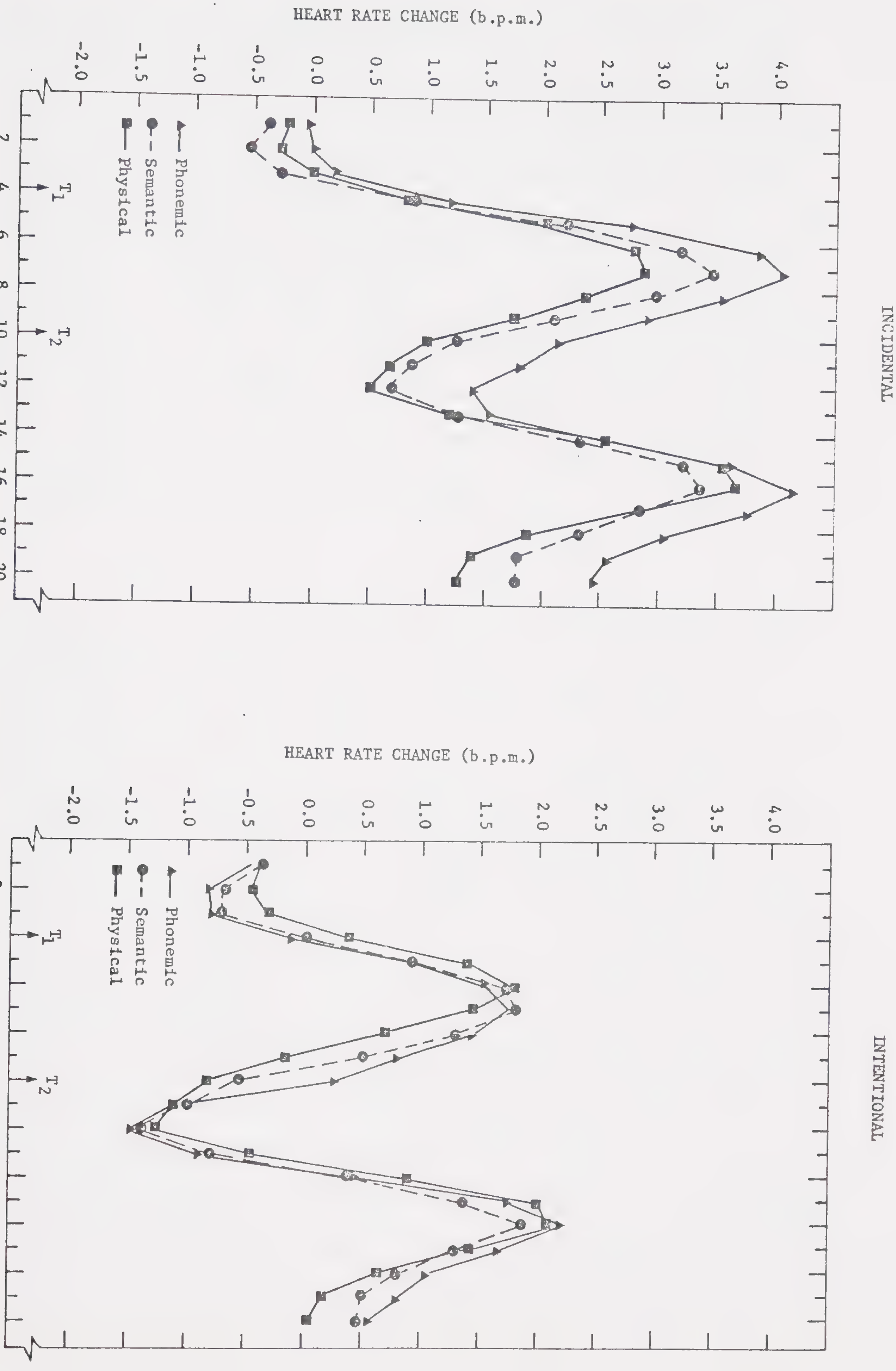
		4-second intervals				
Source	df	1-4	5-8	9-12	13-16	17-20
B(Conditions)	1/42	4.36*	9.52**	13.89**	11.66**	7.56**
W1(Levels)	2/84	.49	2.40	3.14	.76	3.22*
W2(Seconds)	3/126	24.59**	14.75**	67.57**	59.18**	23.63**
W1xB	2.84	.88	1.71	.99	.38	.52
W2xB	3.126	2.46	2.03	1.11	.35	.27
W1xW2	6/252	.42	4.05**	3.02**	2.58*	2.08
W1xW2xB	6/252	.68	.80	1.51	.98	.18

* P<.05 ** P<.01

Within-Ss sec-by-sec HR analyses:effect of levels of processing. Figure 5 presents the second-by-second HR values for the three levels of processing in each of the two learning conditions. Although the shape of the three curves associated with each condition is essentially the same, there appears to be a greater separation of the HR curves in the incidental learning condition than in the intentional learning condition. This observation was confirmed by within-Ss analyses of variance. The ANOVA results revealed a significant main effect for levels in the incidental learning condition; $F(2,42)=3.56, p<.05$; but not for the intentional condition; $F(2,42)<1$. The inter-domain differentiation noticed here is particularly evident in the acceleratory component (and to a lesser extent in the deceleratory component) of the fore-period in the incidental condition (Figure 5). Both phonemic and semantic HR acceleration exceeded that of the physical, but unexpectedly, phonemic cardiac acceleration appeared to be greater than that for semantic; $F(2,42)=4.26, p<.025$.

In order to further evaluate the effect of the different orienting tasks on specific acceleratory and deceleratory components, the HR curves in the trial continuum were divided into five consecutive 4-second intervals, and each interval was subjected to a 3(levels) x 4(seconds) analysis of variance (the results of these analyses are presented in Appendix 3.8). Of particular interest here are the intervals (i) seconds 5 to 8 and (ii) 9 to 12, since these are primarily associated with the acceleratory and deceleratory components of the HR curve respectively in the fore-period. An

FIGURE 5. Mean second-by-second HR value for three levels in each of the two learning conditions. (Each point represents the difference between the mean of the two prestimulus HR values and the HR values for each second. Points marked T_1 and T_2 indicate offset of orienting question and onset of imperative stimulus respectively).


INCIDENTAL
HEART RATE CHANGE (b.p.m.)
SECONDS
Phonemic
Semantic
Physical
T_1
T_2
INTENTIONAL
HEART RATE CHANGE (b.p.m.)
SECONDS
Phonemic
Semantic
Physical
T_1
T_2

examination of the results (see Appendix 3.8) shows that, whereas there were significant main effects for levels in both of these intervals in the incidental condition, there was no effect for the intentional condition in these two intervals. In each of these intervals, HR level for the phonemic task remained higher than that for either the semantic and physical task. These results lend further support to the observation that HR change distinguishes between orienting tasks more markedly in the incidental condition than in the intentional condition, even though the arrangement of the means is in an unexpected direction.

Acceleration. In order to determine whether cardiac acceleration could differentiate between the two learning conditions, the acceleration measure was subjected to a 2 x 3 analysis of variance involving one between-Ss factor (indicental/intentional) and one within-Ss factor (levels). The results of this analysis indicated that HR acceleration from the prestimulus level was significantly higher in the incidental condition (3.91 b.p.m. change) than in the intentional condition (2.15 b.p.m. change); $F(1,42)=8.50, p<.01$. The results are directly opposite to what was predicted. This finding indicates that the increased motivational level of the intentional learning group may have intensified their attention to the task, thus reducing extraneous "somatic noise" (Obrist, 1970 a, 1970 b) which resulted in a reduction in HR. In the above analysis, neither the effect for level, nor the level by group interaction was significant.

To evaluate the degree to which cardiac acceleration could distinguish between the three orienting questions within the two respective learning conditions, within-Ss ANOVAs were performed on the HR acceleration data. The within-Ss analyses revealed a significant difference between levels in HR acceleration in the incidental condition but not in the intentional. The means were; 3.32, 4.52, and 3.90 for physical, phonemic, and semantic orienting tasks respectively; $F(2,42)=4.69, p<.025$. As was evident in the second-by-second analyses, the arrangement order of means was unexpected. The same analysis carried out on the intentional data failed to yield significant differences between levels. The means were 2.10, 2.09, and 2.26 for physical, phonemic, and semantic questions respectively; $F(2,42)<1.0$.

<u>Deceleration</u>. An analysis was performed to determine whether there was a significant difference between learning conditions and between levels in HR deceleration. The first analysis involving 2(conditions) x 3(levels) yielded a highly significant main effect for learning condition; $F(1,42)=12.81, p<.001$. The means were; .578 and -.503 for incidental and intentional groups respectively. This relatively large between-group difference in HR deceleration was apparently due to the fact that cardiac deceleration to all three types of orienting tasks in the incidental group remained well above prestimulus level; whereas, the corresponding deceleration for the intentional group reached well below the prestimulus level. Once again the results were opposite to what was predicted. The same

explanation used to account for the between-group HR acceleration difference may also be used to account for the present between-group HR deceleration difference. That is, the increased motivational level of the intentional group over and above that of the incidental group may have resulted in an increased "quieting" of the somamotor system, and thus a concomitant augmentation of the HR deceleratory component in the intentional group. No other effects of the preceding analysis were significant.

Unlike the analyses for accelerative change, within-Ss analysis of HR deceleration failed to yield a significant level effect in either condition. However, the arrangement of the means in the incidental condition for HR deceleration were similar in trend to that for HR acceleration. In the incidental condition, HR level at peak deceleration remained at a higher level for semantic and phonemic questions than that for physical questions. The respective means were; 1.102, .500, and .275 for phonemic, semantic, and physical orienting tasks respectively; $F(2,42)=2.45, p<.10$.

<u>Discussion</u>.

<u>Incidental and Intentional Learning</u>.

The general features of the fore-period second-by-second HR response curve are consistent with the general intake-rejection hypothesis (Lacey, 1967) and more specifically, its derivative, the two-component hypothesis of Coles et al (1975). The relatively

small initial cardiac deceleration concurrent with the orienting question presentation may indicate externally oriented attention. The succeeding pronounced acceleration may be a correlate of mental activity initiated by the orienting task; and the marked fore-period deceleration may reflect preparation for processing and response execution associated with the imperative stimulus.

However, a note of caution should be sounded at this point. The phasic homeostatic properties of HR change should be recognized as a possible explanation for the HR pattern obtained in this study. While this possibility is recognized, it is unlikely that purely phasic homeostatic reactions would be expected to track the timing of the imposed experimental events in the manner depicted in the HR curves of this study. It is difficult, if not impossible to separate the phasic homeostatic effects from the experimental effects on HR in experiments of this nature.

The present study has demonstrated that continuous second-by-second HR change throughout the trial continuum can distinguish between incidental and intentional learning conditions. But the nature of the distinction is opposite to the predictions of the present study, and to a certain extent, to that of the intake-rejection hypothesis. The present study predicted that since intentional learning is presumably associated with deliberate rehearsal and enhanced motivational levels, one would expect HR level in this condition to be higher than in the incidental condition. The present results show that second-by-second HR level throughout the

entire continuum was uniformly lower in the intentional group than in the incidental group. Additionally, the accelerative and decelerative measures show the same trend in distinguishing between both learning conditions.

The specific findings of lower overall HR level, acceleration, and greater deceleration in the intentional condition, appear to be less consistent with Lacey's theoretical position than with Obrist's et al (1970) general inhibition hypothesis, and also with some recent evidence by Coles (1972), and Duncan-Johnson and Coles (1974). As was mentioned earlier, it is possible that the incrementing of stimulus significance in the intentional condition might have led to a reduction in irrelevant somatic "noise" and thus a concomitant reduction in HR level. This HR deceleration may reflect an increased level of activation associated with the additional task demand in the intentional learning group. Consistent with this notion, are the findings by Coles et al which demonstrated that both phasic and tonic HR deceleration were inversely related to task requirements. That is, HR deceleration increased as a function of increasing task demands.

It should be noted however, that the intake-rejection hypothesis cannot be ruled out as a possible context for the interpretation of the incidental-intentional difference in HR. From the standpoint of this hypothesis, it may be argued that the greater fore-period HR acceleration demonstrated by the incidental learning condition may have been a result of greater uncertainty coupled with

increased anticipatory cognitive activity. The greater fore-period HR deceleration in the intentional condition was probably a result of the strategy adopted by subjects in this condition of just attentively waiting for reception of the imperative stimulus, process it, and rehearse it. That is, it may be suggested that these subjects were less concerned than their incidental learning counterparts with anticipatory processing than with stimulus reception and rehearsal.

Although the present HR data indicates a clear-cut distinction between the two learning conditions, it questions the relatively simple conception of the relationship between cardiac activity and psychological processes advocated by both intake-rejection and cardiac-somatic hypotheses in their present form. In fact, the data points to a more complex set of relationships between HR, task demands, and motivational factors. Thus, more research is needed to clarify these complex relationships.

Incidental vs Intentional Learning: Explanation of their difference in cardiac change.

The separate within-Ss analyses yielded an additional unpredicted distinction between incidental and intentional learning processes. As observed earlier, the analysis of the acceleratory limb and to a lesser extent, the deceleratory limb revealed a greater separation between the HR curves for the three different orienting

tasks in the incidental condition than in the intentional condition. One possible explanation for this phenomenon is that during intentional learning, the stronger motivational effects might have swamped the more subtle effect of the differential demands of the various orienting tasks, thus resulting in a greater compression of the three HR curves in this condition. On the other hand, in the incidental learning condition, the quality of mental activity is primarily determined by the different types of orienting tasks. At present, this is the most plausible explanation (for this reason, the separation of the HR curves in this condition may have been dictated by this differential underlying mental activity).

Levels of Processing.

The prediction that fore-period HR acceleration will be positively related to levels of processing was confirmed in the incidental learning condition only, where it was found that "deeper" orienting questions (i.e., phonemic, and semantic) elicited greater cardiac acceleration than "shallow" (physical) questions. However, as was previously mentioned, the relative ordering of the means was contrary to expectations. That is, cardiac acceleration for the phonemic task exceeded that for the semantic task. Speculatively, the phonemic questions might have induced greater covert verbalization in terms of generating possible answers in advance of the imperative stimulus onset. This suggestion appears to be tenable in light of the information from post-experimental interviews. In these

interviews, subjects claimed to have been more conscious of generating possible matching words to the phonemic orienting questions than they were to the semantic orienting questions. A number of authors (e.g., Obrist et al, 1970; Johnson and Campos, 1967) have suggested a link between covert verbal activity and cardiac acceleration during cognitive task.

Orienting Questions - does processing begin with them?

It should be noted at this point, that the differences in HR acceleration observed between levels in the incidental condition is associated with the various orienting questions, and not with the actual processing of the imperative stimulus. If it is presumed that processing begins exclusively at imperative stimulus onset, then the present HR data yields very little differentiation between levels of processing. On the other hand, if it is assumed that actual mental activity related to the imperative stimulus begins with orienting question onset, then the differential HR acceleration in the incidental condition observed in this study, provides an index of processing depth.

Additionally, it may be argued that the orienting questions are associated with different degrees of stimulus significance. That is, they provide information regarding the processing requirements present at the imperative stimulus onset. According to Sokolov (1963) a signal stimulus is one which elicits a reaction in antici-

pation of an external event or which requires a response. Each of three types of orienting questions presumably demands a different level of subsequent processing. The above argument implies that the orienting questions may be differentiated in terms of their signal value, and that the magnitude of HR change varies as a function of this signal value.

There is some indirect evidence in the literature to support the notion that anticipatory mental operations related to the imperative stimulus start with orienting question onset. Luria and Vinogradova (1959) and Luria (1972 and 1973) suggested on the basis of clinical and empirical evidence that every stimulus-word is embedded in a multi-dimensional matrix comprising of phonemic, semantic, and other dimensions. According to this proposal, a single word in a specific matrix may activate all its associated phonemic or semantic counterparts in that matrix depending on the dimension of the word elicited. For example, the word "sleet" may evoke among other phonemic counterparts "feet" if the subject is questioned about the rhyming characteristic of the word. Similarly, in the present study, the phonemic and semantic orienting questions might have activated the appropriate phonemic or semantic category of words related to the anticipated imperative stimulus. This anticipatory mental activity may have been reflected in a corresponding change in fore-period cardiac activity.

CHAPTER VII

GSR AND LEVELS OF PROCESSING: RESULTS AND DISCUSSION

Results

GSR magnitude, frequency, recovery, and latency to both orienting questions and imperative stimuli were analysed. The rationale for analysing multiple GSR characteristics was stated earlier. The basic notion was that some GSR characteristics reflect certain psychological processes better than others.

The major independent variables under consideration in the present analyses were; the effects of incidental vs intentional learning; and the effects of levels of processing on the above four GSR measures. The analysis of these GSR measures followed closely the analysis of HR. As with the HR analyses, only the correct trials were included. However, the mean number of error trials were small: 1.5 and 2.5 for the incidental and intentional conditions respectively. Detailed results of all relevant statistical analyses are included in Appendix 4. Only those results which are of major interest are presented in this section.

In order to determine whether there were any significant

differences in prestimulus GSR level between conditions and between levels of processing, an analysis of variance involving 2(conditions) x 3(levels) was performed on the mean prestimulus scores. The results of this analysis indicated that there were no such differences in prestimulus levels.

Effect of Incidental vs Intentional Learning.

In order to evaluate the effects of incidental vs intentional learning processes on the GSR measures, analyses of variance were carried out on the GSRs to the orienting questions and imperative stimuli. All of these analyses involving 2(conditions) x 3(levels) uniformly failed to yield significant differences between the two learning conditions. However, these same analyses involving the data from both learning conditions showed a significant levels effect for magnitude and frequency to the orienting questions, but not to the imperative stimulus (see Appendices 4.3 to 4.5 for more details). The within-Ss analyses which are presented next, revealed that the major source of the variance for the levels effect for magnitude and frequency were associated with the incidental condition.

Within-Ss Analyses: The Effect of Levels of Processing.

Magnitude. The mean GSR magnitude scores associated with the three levels of orienting tasks within each of the two learning conditions

are depicted in Figure 6. Inspection of this figure indicates that within the incidental learning condition there is a greater distinction between levels of processing in GSR magnitude than in the intentional condition. This finding is consistent with the recall and HR results. Further examination of this figure shows that, whereas GSR magnitude is positively related to levels of processing in the incidental condition, this was not the case in the intentional condition. Within-Ss analyses of variance confirmed these observations. With regard to the incidental data, there was a significant main effect for levels; $F(2,38)=4.91, p<.025$. The same analyses conducted on the intentional data failed to yield significant differences between levels; $F(2,38)<.10$. The same analyses performed on GSR magnitude scores associated with the imperative stimulus revealed no significant difference between levels in either incidental or intentional condition.

Frequency. The mean GSR frequencies for the three types of orienting tasks in each of the two conditions are presented in Figure 7. Once again, it will be observed that the mean GSR response frequencies arrange themselves closer to the predicted order in the incidental condition than in the intentional condition. Consistent with the previous results, there is a clearer distinction between "shallow" and "deeper" orienting tasks in the incidental condition than in the intentional condition. For the incidental condition the means were: .655, .755, and .760 for physical, phonemic, and semantic respectively. The phonemic and semantic means

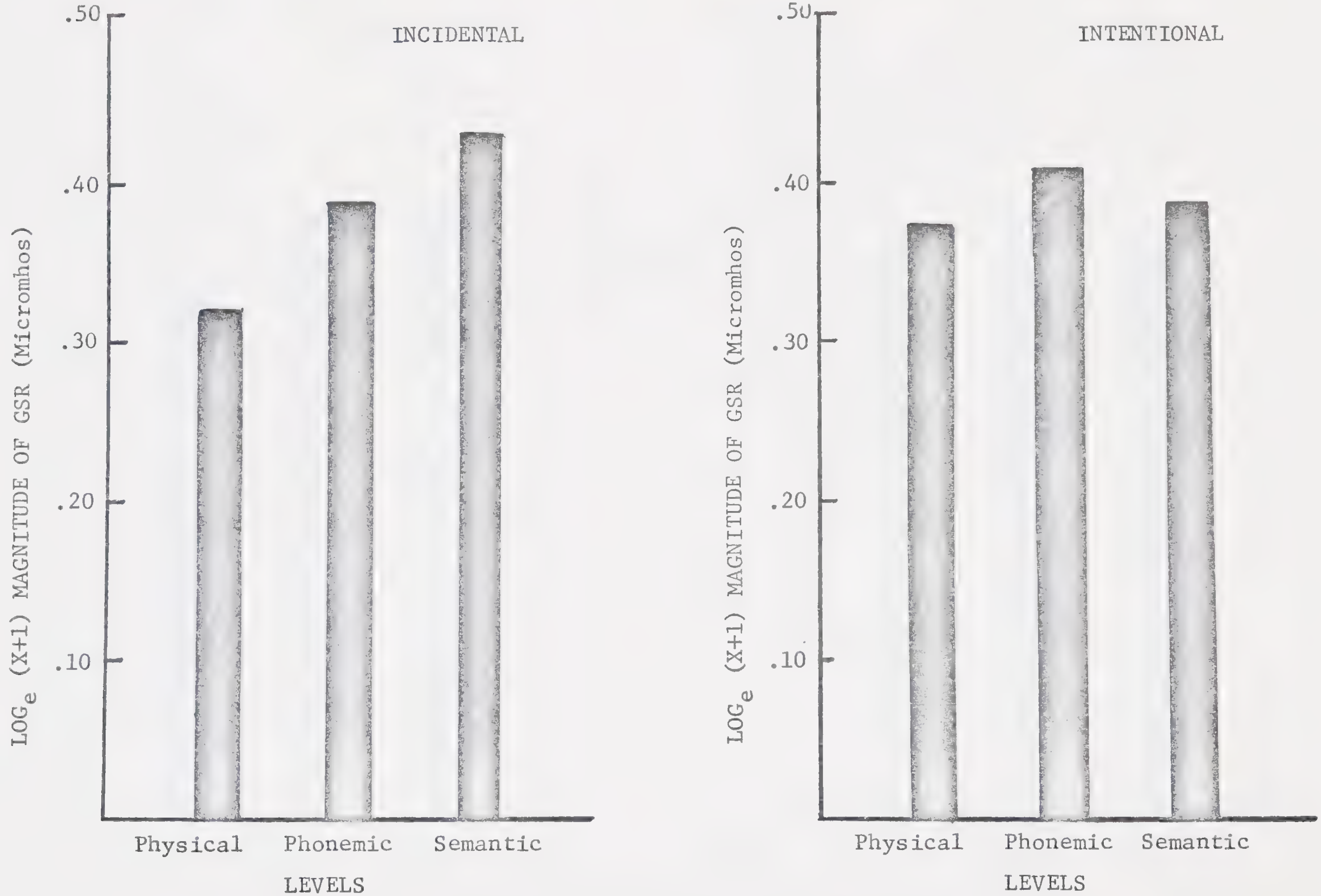


FIGURE 6. Diagram of Mean Log$_e$ Magnitude of GSR to Orienting Questions in Two Learning Conditions.

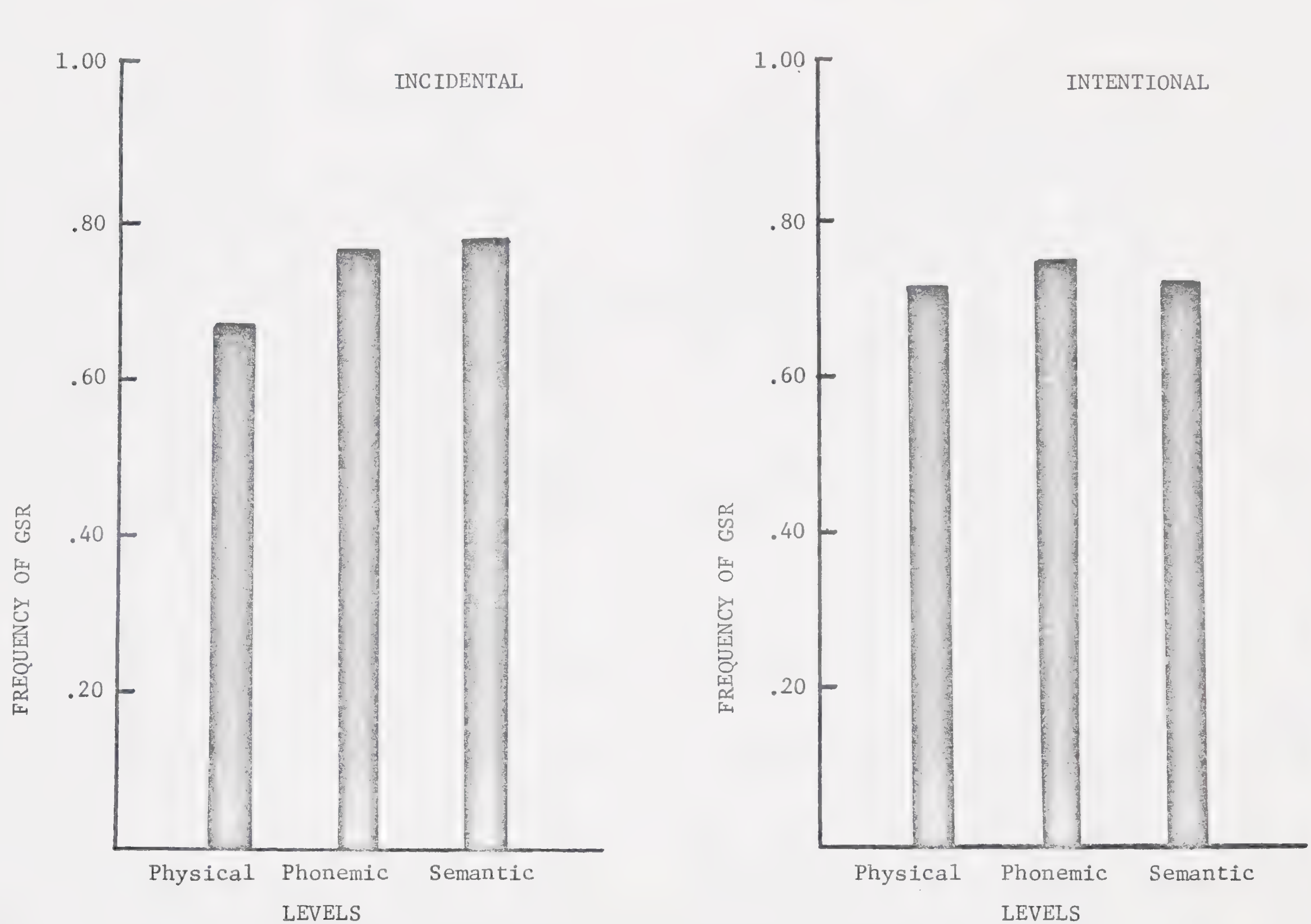


FIGURE 7. Diagram of Mean Frequency of GSR to Orienting Questions in Two Learning Conditions.

appear to be indistinguishable from each other. The corresponding means for the intentional condition were: .705, .745, and .710. Analyses of variance revealed a significant main effect for levels within the incidental condition but not in the intentional condition. Incidental; $F(2,38)=4.45, p<.025$; intentional; $F(2,38)<1.0$. The same analyses carried out on GSR frequencies associated with the imperative stimulus failed to yield significant differences.

Latency. Within-Ss analyses were performed to explore the effects of levels of processing on GSR latencies. The results of these analyses revealed no statistically reliable differences.

Recovery. ANOVAs on recovery rates in each of the two conditions revealed a non-significant level effect. However, a more comprehensive analysis involving the data from both learning conditions was conducted. The rationale for this analysis is based on the findings of Edelberg (1970 and 1972) that GSR recovery rate is primarily related to the degree of mobilization of goal-directed behavior. In the present study goal-directed behavior was influenced chiefly by speed and accuracy, requirements which were equally common to both learning conditions. The analysis yielded a significant levels effect.

The mean recovery rates for the three levels are illustrated in Figure 8. Inspection of this figure shows that the recovery time

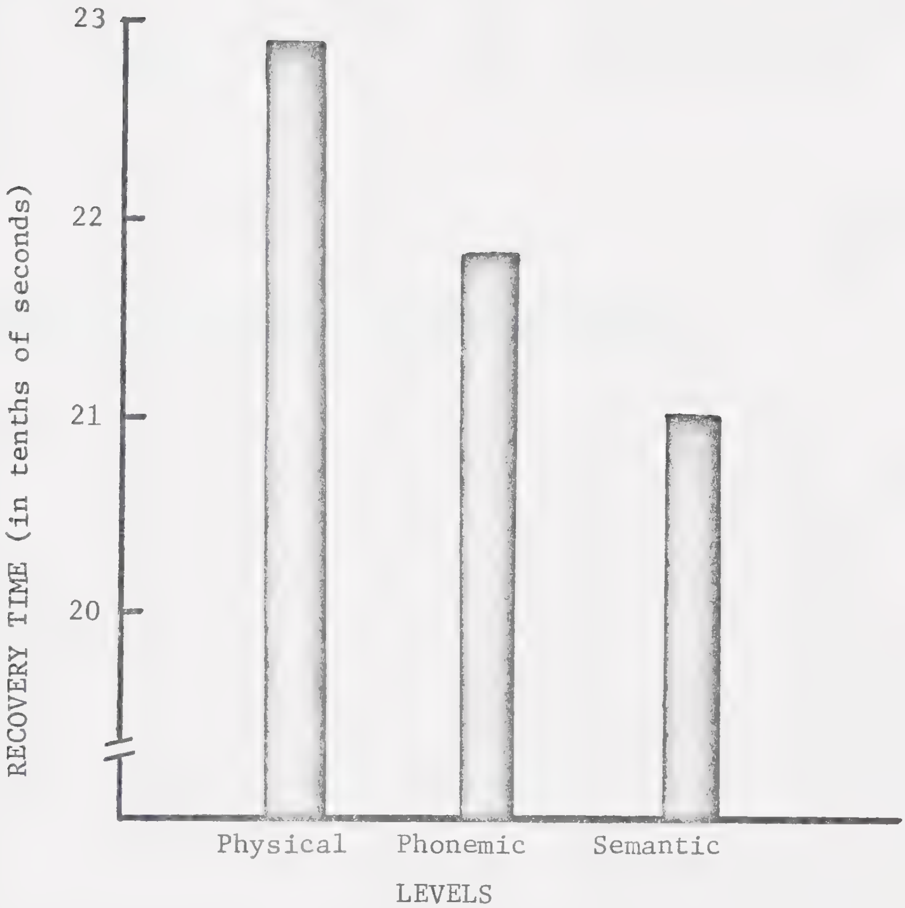


FIGURE 8. Diagram of Mean Recovery Time of GSR to the Imperative Stimulus Averaged Over Learning Conditions.

for semantic processing is faster than that for phonemic, which in turn, is faster than the physical recovery rate; $F(2,76)=3.71, p<.05$. The recovery rates for GSRs associated with the orienting task were not examined because in general, they did not recover sufficiently before the occurrence of another GSR. According to Edelberg (1970), an examination of recovery rates will yield meaningful information only when the GSR response recover at least 50% before a second response occurs.

Orienting Question - Imperative Stimulus Comparisons.

The above comparisons were not a central concern of the present study, but were examined in order to discover whether the present data supported those of previous studies. Previous researchers (e.g., Bernstein et al, 1975) reported that GSR to the imperative stimulus was significantly larger in magnitude and more persistent than that associated with an alerting signal. The present paradigm is comparable to previous designs involving such comparisons. The orienting question may be conceived as an alerting stimulus containing information pertinent to the imperative stimulus.

The orienting question - imperative stimulus differences were evaluated by within-Ss analyses of GSR magnitude and frequency. The results of these analyses showed that GSR magnitude and frequency to the imperative stimulus exceeded that of the orienting question. For GSR magnitude in the incidental condition; $F(1,19)=33.78, p<.001$; and

in the intentional condition; $F(1,19)=20.86, p<.001$. For GSR frequency in the incidental condition; $F(1,19)=101.75, p<.001$; and in the intentional condition; $F(1,19)=23.55, p<.001$. An immediate correct response requirement plus the preparation for stimulus reception and analysis seemed to have accounted for these results.

Discussion.

Contrary to predictions, all of the four GSR measures analysed in this study failed to discriminate directly between the two learning conditions. Perhaps, this may be a result of a manifestation of a ceiling effect. However, in a less direct way, the GSR measures indicated some distinction between the two learning conditions. That is, the within-Ss analyses indicated that GSR characteristics can differentiate between the three types of orienting tasks and thus levels of processing in the incidental condition but not in the intentional condition.

Consistent with the HR data, GSR magnitude and frequency in the incidental condition showed a significant main effect for levels associated with the orienting task, but no such effect was observed for GSR magnitude and frequency associated with the imperative stimulus. As was suggested earlier, it may be that in the present study, autonomic activity associated with the orienting task is a more reliable, though a less direct index of levels of processing than that associated with the imperative stimulus. Admittedly, in

the present study, GSR activity at imperative stimulus onset may be a joint function of levels of processing and preparation to execute a motor response. The present paradigm probably confounds these two requirements. It should be noted that in this study, the emphasis on speed of motor response might have washed out the GSR-related difference between the three levels of processing associated with the imperative stimulus.

On the other hand, GSR activity associated with the orienting task in the incidental condition is relatively free from such confounding influence. The orienting questions appear to have the property of energising or activating a specific quality of anticipatory cognitive activity which, as was mentioned earlier, appears to be more elaborate in phonemic and semantic than in physical tasks. The orienting questions also provide specific information value regarding the processing requirements present at the imperative stimulus. Within this context, orienting questions may be categorized into different levels of significance. The signal value of each type of orienting question will vary as a function of the above two functional characteristics. If this assumption is correct, then it may be concluded that the GSR activity associated with the orienting questions did provide some indication of levels of processing. This proposal gains support from Bernstein, Taylor, and Weinstein (1975), who demonstrated that verbally incrementing stimulus significance resulted in a concomitant incrementing of GSR magnitude. The findings with regard to GSR magnitude and frequency also obtain some support from Das (1969) and Mulcahy (1972). In

these studies, it was demonstrated that the processing of simple sensory stimuli may be distinguished from the processing of more complex verbal stimuli, on the basis of GSR magnitude and frequency.

It is interesting to note that in the present study, GSR recovery rate was the only autonomic measure to discriminate between levels of processing at imperative stimulus onset. As predicted, GSR recovery rate was positively related to levels of processing. This finding is in accord with Edelberg (1970). In this study, a reaction time paradigm was used and it was discovered that recovery rate was the only GSR measure to distinguish between levels of psychological significance, when GSR magnitude and frequency failed to do so. This finding support the previously presented notion, that the GSR is a group of separate responses, which are distinguishable by their unique relationships to different underlying psychological processes.

According to Edelberg, fast recovery rates may be positively related to mobilization for goal-directed behavior. In the present study, goal-directed behavior is decision-making; the speed of which is dependent on processing requirements of the task. This proposal implies that the degree of goal-orientation should be a positive function of levels of processing. Hence, deeper levels of processing should be associated with faster recovery times than shallow-level processing. The finding with respect to GSR recovery rates indicates that levels of processing may not be exclusively related to cognitive activity per se, but also to other related psychological

processes such as motivation and/or arousal. The recovery data suggest that levels of processing may also be systematically related to the motivational domain.

Finally, the above suggestion argues for the examination of a variety of GSR measures in any attempt to achieve a more comprehensive indexing of levels of processing. Although the autonomic data is only suggestive, they do lend some support for the proposal of a systematic relationship between the central information processing and arousal system, and peripheral autonomic activity.

CHAPTER VIII

CONCLUSIONS

Levels of processing is an important concept in memory. The general pattern of the results attests to this. Although the present design deviates somewhat from that of Craik and Tulving (1975), essentially the same pattern of recall results was obtained. This finding suggests that the basic phenomenon of levels of processing in memory appears to be a robust one. Nevertheless, despite the basic similarities of the two sets of performance data, there were some differences between the results of the present study and that of Craik and Tulving's.

The most notable difference was that recall levels in the present study was markedly higher. A number of factors in the present design might have interacted with the levels of processing effect to produce this increment in overall recall performance. It was suggested that increased arousal levels, the relatively short list length, and both the comparatively long ISI and ITI were prime factors producing this difference in results. These factors should be taken into consideration in research with levels of processing; they interact with it and influence memorial consequences.

Incidental and intentional learning were both studied here,

the difference between them are briefly discussed next. Within the incidental learning context, it appears that the experimenter, by means of the different orienting questions, exerts more direct control over the type of processing the subject applies to the stimuli - a type of control which he lacks in the intentional learning condition. The differential effects of orienting questions are masked by the overriding concern for recall which the subject develops under intentional learning condition.

The general pattern of the HR curve is consistent with the basic tenets of the intake-rejection hypothesis (lacey et al, 1967) and its derivative, the two-component model (Coles et al, 1975). Thus, HR acceleration which is observed following the orienting question reflects cognitive activity; and the subsequent deceleration which preceded the imperative stimulus reflects preparatory activity. The data from the present study indicate more complex relationships between HR change and qualitatively distinct psychological processes. For example, the effect on HR of the interaction between encoding and motivation has not been studied. An experiment for examining the interaction can be designed in which motivational levels are manipulated while encoding levels are constant. This type of research may help to broaden the base of both the intake-rejection and cardiac-somatic models of HR change.

The states of the central nervous system which determine the efficiency of information processing are too complex to be adequately reflected in a single psychophysiological channel or response

characteristic. Several psychophysiological indices should be examined. The fact that HR discriminated between learning conditions when GSR did not, and also to a lesser extent, the fact that GSR recovery rate to the imperative stimulus differentiated between levels of processing when other GSR measures failed, demonstrate the need for this.

Changes in HR and GSR magnitude, frequency, and recovery were found to reflect levels of processing to a certain extent under incidental learning. The present findings indicate that psychophysiological activity provide further information in addition to performance measures which increase our understanding of such concepts as levels of processing. These measures also help to enhance the empirical status of this explanatory concept. Further, the study of psychophysiological measures in conjunction with other types of response measures contributes to the knowledge of the role of central nervous system mechanisms which regulate arousal, activation, and effort in information processing.

Finally, the recall results under the incidental learning condition obtained in the present study and those of previous studies (Craik and Tulving, 1975; Lawson, 1976) may be interpreted from an alternative perspective. It may be suggested that semantic encoding is more productive, not only because it is deeper or more elaborate, but also because it is more consistent with retrieval strategies. That is, it is more congruent with the information restructuring processes the subject employs at the time of recall.

In other words, it is suggested that at least part of the reason why non-semantic items are recalled poorly under incidental learning, is because the orienting question interferes with or prevents the items from being stored for retrieval. Furthermore, the process of recall is apparently closer to the requirement of semantic encoding. An experiment which specifically encourages the subject to use non-semantic codes as a basis of reconstructing stored information for the purpose of retrieval may facilitate non-semantic recall. Supposing that a subject is asked to recall the non-semantic characteristics of the stimulus which were attended to because of the orienting question. Would their recall be better than that of the semantic characteristics? In short, questions like this have to be examined thoroughly before reliable conclusions can be drawn regarding the 'depth' of semantic vs non-semantic memory trace.

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APPENDIX 1

Materials prepared for the study.

Appendix 1.1

List of words and questions used in the experiment

and procedure for selection of questions.

Word	Rhyme question	Category question
SPEECH	each	a form of communication
CHEEK	teak	a part of the body
HONEY	funny	a type of food
SHEEP	leap	a type of farm animal
COPPER	stopper	a type of metal
MONK	trunk	a type of clergy
DAISY	crazy	a type of flower
CART	start	a type of vehicle
ROBBER	clobber	a type of criminal
WITCH	rich	associated with magic
TWIG	big	a part of a tree
DRILL	fill	a type of implement
MOAN	prone	a human sound
SINGER	ringer	a type of entertainer
CHERRY	very	a type of fruit
EARL	pearl	a type of nobility
WEEK	peak	a division of time
PAIL	whale	a type of container
TROUT	bout	a type of fish
GRAM	tram	a type of measurement
WOOL	pull	a type of material
CLIP	ship	a type of office supply
LARK	park	a type of bird
JADE	raid	a type of precious stone
SLEET	feet	a type of weather
RICE	dice	a type of grain
TIRE	fire	a round object
DANCE	stance	a type of physical activity
FLOOR	sore	a part of a room
TRIBE	scribe	a group of people

The six different types of questions (3 levels x 2 response types) were colour-coded. For example, "Case Yes" questions were assigned the colour red, "Case No" questions the colour blue, "Rhyme Yes" questions yellow, and so on. Thirty 1/2" plastic discs, five of each of the six colours were placed in a container and the experimenter "blindly" selected a disc and the appropriate question was assigned to each consecutive word. This procedure was repeated for the four question formats. Negative questions were drawn from the pool of unused questions in that particular format.

Appendix 1.2

Presentation sequence No.1

S# ________ Grp.________

Trial	Sequence	Choice	RT
1	Rhyme Yes	______	______
2	Case No	______	______
3	Categ. Yes	______	______
4	Case Yes	______	______
5	Categ. Yes	______	______
6	Rhyme Yes	______	______
7	Categ. No	______	______
8	Rhyme No	______	______
9	Categ. No	______	______
10	Categ. Yes	______	______
11	Rhyme No	______	______
12	Categ. No	______	______
13	Case No	______	______
14	Case Yes	______	______
15	Case Yes	______	______
16	Rhyme No	______	______
17	Categ. No	______	______
18	Case Yes	______	______
19	Rhyme No	______	______
20	Case No	______	______
21	Case No	______	______
22	Categ. Yes	______	______
23	Case Yes	______	______
24	Rhyme No	______	______
25	Categ. No	______	______
26	Rhyme Yes	______	______
27	Rhyme Yes	______	______
28	Rhyme Yes	______	______
29	Case No	______	______
30	Categ. Yes	______	______

Appendix 1.3

Presentation sequence No.2

S# ________ Grp.________

Trial	Sequence	Choice	RT
1	Case No	______	______
2	Categ. No	______	______
3	Categ. Yes	______	______
4	Case Yes	______	______
5	Rhyme No	______	______
6	Rhyme No	______	______
7	Categ. Yes	______	______
8	Categ. No	______	______
9	Rhyme No	______	______
10	Categ. No	______	______
11	Case Yes	______	______
12	Rhyme Yes	______	______
13	Rhyme Yes	______	______
14	Case No	______	______
15	Rhyme Yes	______	______
16	Rhyme No	______	______
17	Case Yes	______	______
18	Categ. Yes	______	______
19	Case No	______	______
20	Case Yes	______	______
21	Rhyme Yes	______	______
22	Categ. Yes	______	______
23	Rhyme No	______	______
24	Case Yes	______	______
25	Case No	______	______
26	Categ. No	______	______
27	Categ. No	______	______
28	Case No	______	______
29	Categ. Yes	______	______
30	Rhyme Yes	______	______

Appendix 1.4

Presentation sequence No.3

S#________ Grp.________

Trial	Sequence	Choice	RT
1	Rhyme Yes	______	______
2	Rhyme No	______	______
3	Case No	______	______
4	Categ. Yes	______	______
5	Case No	______	______
6	Case Yes	______	______
7	Categ. No	______	______
8	Categ. Yes	______	______
9	Rhyme Yes	______	______
10	Case Yes	______	______
11	Rhyme Yes	______	______
12	Categ. No	______	______
13	Rhyme No	______	______
14	Case Yes	______	______
15	Case Yes	______	______
16	Case Yes	______	______
17	Categ. Yes	______	______
18	Rhyme No	______	______
19	Categ. No	______	______
20	Rhyme Yes	______	______
21	Case No	______	______
22	Case No	______	______
23	Rhyme Yes	______	______
24	Categ. No	______	______
25	Rhyme No	______	______
26	Case No	______	______
27	Categ. No	______	______
28	Categ. Yes	______	______
29	Rhyme No	______	______
30	Categ. Yes	______	______

Appendix 1.5

Presentation sequence No.4

S#________ Grp.________

Trial	Sequence	Choice	RT
1	Categ. Yes	______	______
2	Case Yes	______	______
3	Categ. No	______	______
4	Case Yes	______	______
5	Rhyme Yes	______	______
6	Rhyme No	______	______
7	Case No	______	______
8	Categ. Yes	______	______
9	Categ. Yes	______	______
10	Categ. No	______	______
11	Rhyme No	______	______
12	Case No	______	______
13	Rhyme No	______	______
14	Case Yes	______	______
15	Case No	______	______
16	Categ. No	______	______
17	Case No	______	______
18	Rhyme Yes	______	______
19	Categ. Yes	______	______
20	Case Yes	______	______
21	Rhyme No	______	______
22	Categ. No	______	______
23	Case Yes	______	______
24	Categ. Yes	______	______
25	Case No	______	______
26	Rhyme Yes	______	______
27	Categ. No	______	______
28	Rhyme Yes	______	______
29	Rhyme Yes	______	______
30	Rhyme No	______	______

APPENDIX 2

ANOVA Summary Tables of Performance Measures.

APPENDIX 2.1

ANOVA Summary Table for Decision Latency:

2(groups) x 3(levels) x 2(response types).

SOURCE	DF	SS	MS	F
BETWEEN				
SUBJ	43	4346215.65		
B1(GROUPS)	1	119425.09	119425.09	1.187
EB1(ERROR)	42	4226790.55	100637.87	
WITHIN				
W1(LEVELS)	2	1688806.30	844403.15	72.580**
W1B1	2	17559.85	8779.92	0.755
EW1B1(ERROR)	84	977261.52	11634.07	
W2(RESPONSE TYPES)	1	30016.00	30016.00	2.311
W2B1	1	366.37	366.37	0.028
EW2B1(ERROR)	42	545575.80	12989.90	
W12	2	53183.39	26591.70	4.023*
W12B1	2	48361.12	24180.56	3.659*
EW12B1(ERROR)	84	555169.82	6609.16	
W	220	3916300.17		
TOTAL	263	8262515.81		

* $p<.05$ ** $p<.01$

APPENDIX 2.2

Probability matrix for Schéffe multiple comparison of decision latency means for positive and negative responses collapsed over groups

POSITIVE				NEGATIVE			
Means Levels	563 Phys.	741 Phon.	778 Sem.	Means Levels	582 Phys.	695 Phon.	741 Sem.
Phys.	____	0.0	.00	Phys.	____	0.001	0.0
Phon.		____	0.45	Phon.		____	0.28

APPENDIX 2.3

Probability matrix for Schéffe multiple comparison of decision latencies at each level averaged over YES-NO response types.

INCIDENTAL				INTENTIONAL			
Means Levels	557 Phys.	685 Phon.	744 Sem.	Means Levels	589 Phys.	750 Phon.	774 Sem.
Phys.	____	.02	.002	Phys.	____	.02	.002
Phon.		____	.435	Phon.		____	.740

APPENDIX 2.4

ANOVA Summary Table for Recall Performance:

2(groups) x 3(levels) x 2(response types).

SOURCE	DF	SS	MS	F
BETWEEN				
SUBJ	43	67859.09		
B1(GROUPS)	1	22183.33	22183.33	20.398**
EB1(ERROR)	42	45675.76	1087.52	
WITHIN				
W1(LEVELS)	2	42554.55	21277.27	74.395**
W1B1	2	1821.21	910.61	3.184*
EW1B1(ERROR)	84	24024.24	286.00	
W2(RESPONSE TYPES)	1	11468.18	11468.18	28.338**
W2B1	1	801.52	801.52	1.981
EW2B1(ERROR)	42	16996.97	404.69	
W12	2	2354.55	1177.27	2.490
EW12B1(ERROR)	84	39721.21	472.87	
W	220	140200.00		

TSQ/N= 302740.91 N=264 SST=208059.09

* p<.05 ** p<.01

APPENDIX 2.5

ANOVA summary table: incidental condition YES-NO
Schéffe comparison for recall at the physical level.

SOURCE	SS	MS	DF	F	P
Resp.Type	0.445	445.45	1	1.96	0.169
Error	0.955	227.27	42		

ANOVA summary table: incidental condition YES-NO
Schéffe comparison for recall at the phonemic level.

SOURCE	SS	MS	DF	F	P
Resp.Type	0.295	2945.45	1	16.68	.0002
Error	0.742	176.62	42		

ANOVA summary table: incidental condition YES-NO
Schéffe comparison for recall at the semantic level.

SOURCE	SS	MS	DF	F	P
Resp.Type	0.819	8181.75	1	12.96	0.0008
Error	0.265	631.17	42		

APPENDIX 2.6

ANOVA summary table: intentional condition YES-NO
Schéffe comparison for recall at the physical level.

SOURCE	SS	MS	DF	F	P
Resp.Type	0.445	445.45	1	0.63	0.430
Error	0.295	701.73	42		

ANOVA summary table: intentional condition YES-NO
Schéffe comparison for recall at the phonemic level.

SOURCE	SS	MS	DF	F	P
Resp.Type	0.736	736.31	1	0.96	0.334
Error	.324	771.00	42		

ANOVA summary table: intentional condition YES-NO
Schéffe comparison for recall at the semantic level.

SOURCE	SS	MS	DF	F	P
Resp.Type	0.233	2327.19	1	4.63	0.037
Error	0.211	502.17	42		

APPENDIX 2.7

ANOVA summary table: between groups comparison for recall at the physical level.

SOURCE	SS	MS	DF	F	P
Groups	0.524	5236.36	1	17.52	0.0001
Error	0.126	298.92	42		

ANOVA summary table: between groups comparison for recall at the phonemic level.

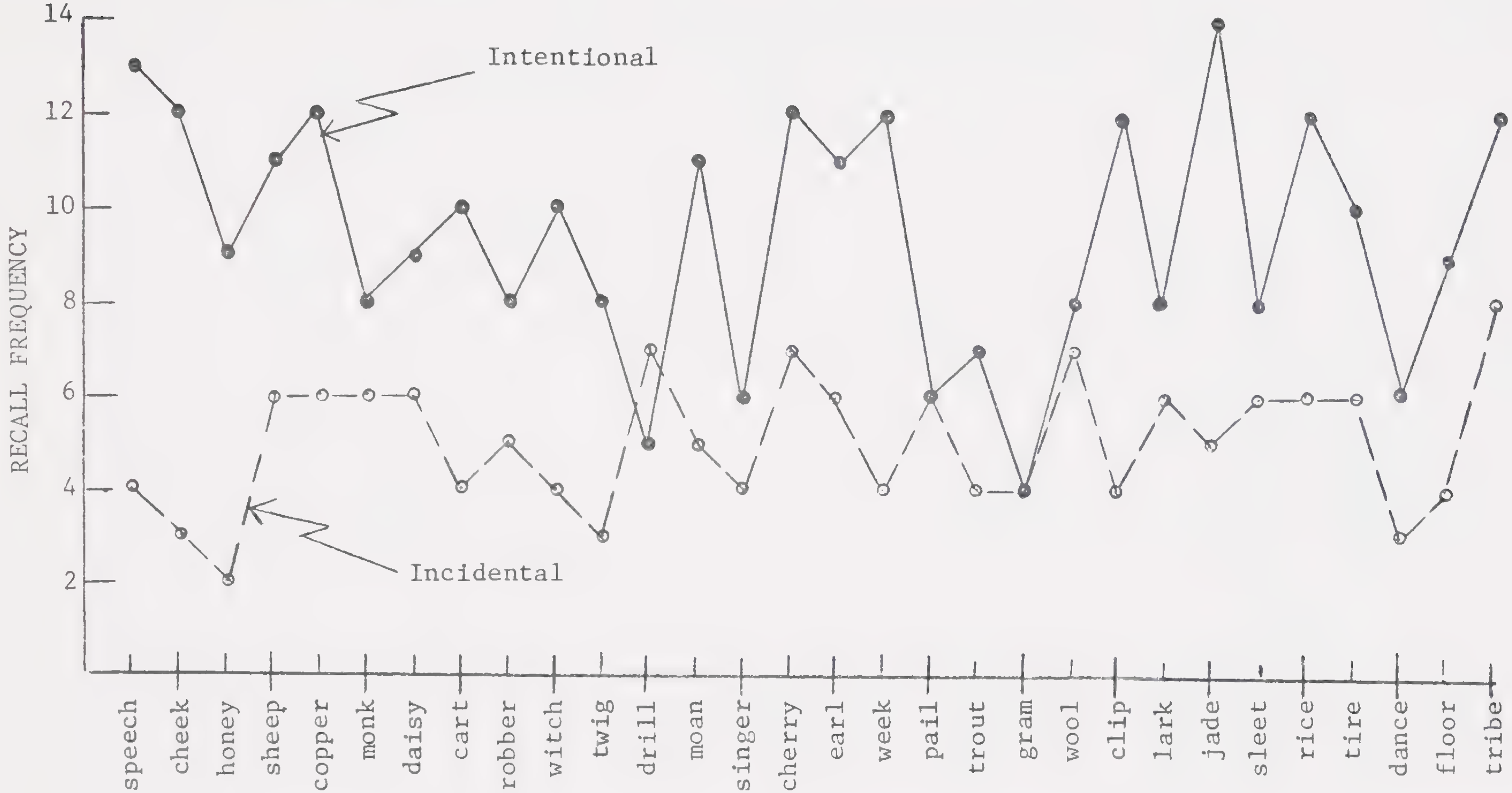
SOURCE	SS	MS	DF	F	P
Groups	0.545	5456.82	1	19.03	0.00008
Error	0.120	286.69	42		

ANOVA summary table: between groups comparison for recall at the semantic level.

SOURCE	SS	MS	DF	F	P
Groups	0.131	1309.06	1	5.36	0.03
Error	0.103	244.16	42		

APPENDIX 2.8

Recall Frequency for Each Word as a Function of its Serial Position



APPENDIX 3

ANOVA Summary Tables of HR Measures.

APPENDIX 3.1

ANOVA Summary Table for Pre-Stimulus Levels:

2(groups) x 3(levels).

SOURCE	DF	SS	MS	F
SUBJECTS	43	19144.41		
B1(GROUPS)	1	727.75	727.75	1.660
EB1(ERROR)	42	18416.67	438.49	
W1(LEVELS)	2	14.20	7.10	2.50
W1B1	2	0.42	0.21	.074
EW1B1(ERROR)	84	238.71	2.84	
W	88	253.33		
TSQ/N=	668588.06	N= 132	SST=	19397.74

* p<.05   ** p<.01

APPENDIX 3.2

ANOVA Summary Table for sec x sec HR Change:

2(groups) x 3(levels).

SOURCE	DF	SS	MS	F
SUBJECTS	43	5545.02		
B1(GROUPS)	1	1526.93	1526.93	15.961**
EB1(ERROR)	42	4018.09	95.67	
W1(LEVELS)	2	84.96	42.48	1.818
W1B1	2	54.46	27.23	1.165
EW1B1(ERROR)	84	1962.73	23.37	
W2(SECONDS)	19	3154.04	166.00	33.249**
W2B1	19	211.41	11.13	2.229**
EW2B1(ERROR)	798	3984.15	4.99	
W12	38	90.94	2.39	2.756**
W12B1	38	13.01	0.34	0.394
EW12B1(ERROR)	1596	1386.04	0.87	
W	2596	10941.74		
TSQ/N=	3668.01	N= 2640	SST=	16486.76

* p<.05 ** p<.01

APPENDIX 3.4

ANOVA Summary Table of sec x sec HR Change

for Early vs Late Trials.

SOURCE	DF	SS	MS	F
SUBJECTS	43	11020.34		
B1(GROUPS)	1	3046.46	3046.46	16.046**
EB1(ERROR)	42	7973.88	189.85	
W1(LEVELS)	2	188.26	94.13	1.916
W1B1	2	106.03	53.02	1.079
EW1B1(ERROR)	84	4127.56	49.14	
W2(TRIALS)	1	143.16	143.16	2.789
W2B1	1	45.10	45.10	0.879
EW2B1(ERROR)	42	2155.71	51.33	
W3(SECONDS)	19	6350.49	334.24	33.474**
W3B1	19	420.19	22.12	2.215**
EW3B1(ERROR)	798	7968.07	9.99	
W12	2	25.94	12.97	0.340
W12B1	2	47.83	23.91	0.627
EW12B1(ERROR)	84	3205.60	38.16	
W13	38	192.26	5.06	2.899**
W13B1	38	27.26	0.72	0.411
EW13B1(ERROR)	1596	2785.23	1.75	
W23	19	69.05	3.63	1.915**
W23B1	19	85.84	4.52	2.381**
EW23B1(ERROR)	798	1514.14	1.90	
W123	38	117.06	3.08	2.011**
W123B1	38	61.94	1.63	1.064*
EW123B1(ERROR)	1596	2444.92	1.53	
W	5236	32081.65		
TSQ/N=	7286.81	N= 5280	SST=	43101.99

* p<.05   ** p<.01

APPENDIX 3.5

ANOVA Summary Table of Pre-Stimulus HR Change

for Early vs Late Trials.

SOURCE	DF	SS	MS	F
SUBJECTS	43	38309.22		
B1(GROUPS)	1	1455.40	1455.40	1.659
EB1(ERROR)	42	36853.81	877.47	
W1(LEVELS)	2	24.00	12.00	2.432
W1B1	2	0.33	0.17	0.033
EW1B1(ERROR)	84	414.40	4.93	
W2(TRIALS)	1	209.43	209.43	14.879**
W2B1	1	1.54	1.54	0.109
EW2B1(ERROR)	42	591.20	14.08	
W12	2	2.07	1.03	0.287
W12B1	2	3.01	1.50	0.418
EW12B1(ERROR)	84	301.84	3.59	
W	220	1547.81		
TSQ/N=	1338050.22	N= 264	SST=	39857.02

* $p<.05$ ** $p<.01$

APPENDIX 3.6

ANOVA Summary Table of sec x sec HR Change for Levels Within the Incidental Condition.

SOURCE	DF	SS	MS	F
SUBJECTS	21	2172.18		
W1(LEVELS)	2	137.23	68.62	3.564*
EW1B(ERROR)	42	808.70	19.25	
W2(SECONDS)	19	1981.18	104.27	20.436**
EW2B(ERROR)	399	2035.85	5.10	
W12	38	48.31	1.27	1.385*
EW12B	798	732.51	0.92	
W	1298	5743.77		
TSQ/N=	4964.07	N= 1320	SST=	7915.95

* p<.05   ** p<.01

APPENDIX 3.7

ANOVA Summary Table of sec x sec HR Change for

Levels Within the Intentional Condition.

SOURCE	DF	SS	MS	F
SUBJECTS	21	1845.91		
W1(LEVELS)	2	2.19	1.09	0.040
EW1B(ERROR)	42	1154.03	27.48	
W2(SECONDS)	19	1384.27	72.86	14.921**
EW2B(ERROR)	399	1948.30	4.88	
W12	38	55.64	1.46	1.788*
EW12B	798	653.54	0.82	
W	1298	5197.97		
TSQ/=	230.87	N= 1320	SST=	7043.87

* p<.05   ** p<.01

APPENDIX 3.8

ANOVA for the five consecutive 4-second intervals involving 3(levels) x 4(seconds).

SOURCE	DF	4-second intervals 1-4	5-8	9-12	13-16	17-20
INCIDENTAL						
W1(LEVELS)	2/42	.85	4.26*	4.28*	.70	3.59*
W2(SECONDS)	3/63	17.93**	11.66**	30.82**	23.38**	11.20**
W1xW2	6/126	.26	.77	.46	1.87	.74
INTENTIONAL						
W1(LEVELS)	2/42	.55	.05	.33	.45	.51
W2(SECONDS)	3/63	8.08**	4.90**	36.88**	37.18**	13.29**
W1xW2	6/126	1.08	4.15**	3.14**	1.69	1.52

* p<.05   ** p<.01

APPENDIX 3.9

ANOVA Summary Table of HR Acceleration:

Incidental vs Intentional Condition.

Source	DF	SS	MS	F
SUBJECTS	43	607.59		
B1(GROUPS)	1	102.26	102.26	8.499**
EB1(ERROR)	42	505.33	12.03	
W1(LEVELS)	2	7.96	3.98	2.175
W1B1	2	8.38	4.19	2.289
EW1B1(ERROR)	84	153.70	1.83	
W	88	170.04		
TSQ/N=	1211.27	N= 132	SST=	777.63

* p<.05   ** p<.01

APPENDIX 3.10

ANOVA Summary Table of HR Acceleration for

Levels Within the Incidental Condition.

SOURCE	DF	SS	MS	F
SUBJECTS	21	299.48		
W1(LEVELS)	2	15.91	7.95	4.690*
EW1B(ERROR)	42	71.23	1.70	
W	44	87.14		
TSQ/N=	1008.70	N= 66	SST=	386.62

* p<.05   ** p<.01

APPENDIX 3.11

ANOVA Summary Table of HR Acceleration for

Levels Within the Intentional Condition.

SOURCE	DF	SS	MS	F
SUBJECTS	21	205.85		
W1(LEVELS)	2	0.43	0.21	0.109
EW1B(ERROR)	42	82.47	1.96	
W	44	82.90		
TSQ/N=	304.83	N= 66	SST=	288.75

* p<.05   ** p<.01

APPENDIX 3.12

ANOVA Summary Table of HR Deceleration:

Incidental vs Intentional Condition.

SOURCE	DF	SS	MS	F
SUBJECTS	43	661.61		
B1(GROUPS)	1	161.22	161.22	13.532**
EB1(ERROR)	42	500.39	11.91	
W1(LEVELS)	2	4.63	2.31	1.167
W1B1	2	3.73	1.86	0.940
EW1B1(ERROR)	84	166.53	1.98	
W	88	174.89		
TSQ/N=	30.34	N= 132	SST=	836.49

* p<.05 ** p<.01

APPENDIX 3.13

NOTE

The other HR measures not discussed so far were largely non-productive in providing inter-domain differentiation. Analysis of fore-period HR deceleration in the incidental condition show that the HR level for semantic and phonemic orienting questions maintain their higher level than that for the physical orienting questions. This might have been due to the continuation of more elaborate mental activity associated with the former two types of questions up to the onset of the imperative stimulus. Alternatively, it may be argued that the HR deceleration measure is not independent of initial acceleration, and that both of these measures are positively related merely on the basis of reequilibration dynamics. From the present findings, it appears that fore-period acceleration is the most appealing HR measure for differentiating between learning conditions and between levels of processing. This is so in the present paradigm since it is difficult to unconfound HR deceleration due to preparation for stimulus processing from that due to preparation for executing a motor response.

APPENDIX 4

ANOVA Summary Tables of GSR Measures.

APPENDIX 4.1

ANOVA Summary Table of Pre-Stimulus GSR Magnitude:

2(groups) x 3(levels)

SOURCE	DF	SS	MS	F
SUBJECTS	39	25.27		
B1(GROUPS)	1	0.06	0.06	0.091
EB1(ERROR)	38	25.21	0.66	
W1(LEVELS)	2	0.00	0.00	0.523
W1B1	2	0.00	0.00	0.531
EW1B1(ERROR)	76	0.16	0.00	
W	80	0.16		
TSQ/N=	971.54	N= 120	SST=	25.43

* p<.05 ** p<.01

APPENDIX 4.2

ANOVA Summary Table of Pre-Stimulus GSR Magnitude
for Early vs Late Trials

SOURCE	DF	SS	MS	F
SUBJECTS	39	49.81		
B1(GROUPS)	1	0.13	0.13	0.102
EB1(ERROR)	38	49.67	1.31	
W1(LEVELS)	2	0.01	0.00	0.748
W1B1	2	0.00	0.00	0.282
EW1B1(ERROR)	76	0.27	0.00	
W2(TRIALS)	1	0.02	0.02	0.269
W2B1	1	0.01	0.01	0.152
EW2B1(ERROR)	38	2.54	0.07	
W12	2	0.01	0.00	0.981
W12B1	2	0.01	0.00	0.988
EW12B1(ERROR)	76	0.26	0.00	
W	200	3.12		
TSQ/N=	1935.15	N= 240	SST=	52.93

* p<.05 ** p<.01

APPENDIX 4.3

ANOVA Summary Table of GSR Magnitude to the Orienting Task: 2(groups) x 3(levels)

SOURCE	DF	SS	MS	F
SUBJECTS	39	12.91		
B1(GROUPS)	1	0.01	0.01	0.015
EB1(ERROR)	38	12.90	0.34	
W1(LEVELS)	2	0.09	0.04	3.994*
W1B1	2	0.04	0.02	1.733
EW1B1(ERROR)	76	0.83	0.01	
W	80	0.95		
TSQ/N=	16.79	N= 120	SST=	13.86

* $p<.05$ ** $p<.01$

APPENDIX 4.4

ANOVA Summary Table of GSR Frequency to the Orienting Task: 2(groups) x 3(levels).

SOURCE	DF	SS		MS	F
SUBJECTS	39	5.58			
B1(GROUPS)	1	0.00		0.00	0.002
EB1(ERROR)	38	5.58		0.15	
W1(LEVELS)	2	0.11		0.05	3.620*
W1B1	2	0.05		0.03	1.688
EW1B1(ERROR)	76	1.14		0.02	
W	80	1.30			
TSQ/N=	62.50	N=	120	SST=	6.88

* p<.05   ** p<.01

APPENDIX 4.5

ANOVA Summary Table of GSR Recovery Rate to the

Imperative Stimulus: 2(groups) x 3(levels).

SOURCE	DF	SS	MS	F
SUBJECTS	39	11890.32		
B1(GROUPS)	1	92.40	92.40	0.298
EB1(ERROR)	38	11797.92	310.47	
W1(LEVELS)	2	64.49	32.25	3.697*
W1B1	2	6.94	3.47	0.398
EW1B1(ERROR)	76	662.89	8.72	
W	80	734.33		

TSQ/N= 57575.10 N= 120 SST= 12624.65

* p<.05 ** p<.01

APPENDIX 4.6

ANOVA Summary Table: Within-Ss Analysis of GSR Magnitude to the Orienting Task for Incidental Condition.

SOURCE	DF	SS		MS	F
SUBJECTS	19	5.61			
W1(LEVELS)	2	0.11		0.05	4.908*
EW1B(ERROR)	38	0.42		0.01	
W	40	0.53			
TSQ/N=	8.11	N=	60	SST=	6.14

* p<.05   ** p<.01

APPENDIX 4.7

ANOVA Summary Table: Within-Ss Analysis of GSR Magnitude to the Orienting Task for Intentional Condition.

SOURCE	DF	SS	MS	F
SUBJECTS	19	7.30		
W1(LEVELS)	2	0.02	0.01	0.735
EW1B(ERROR)	38	0.41	0.01	
W	40	0.42		
TSQ/N=	8.69	N= 60	SST=	7.72

* p<.05   ** p<.01

APPENDIX 4.8

ANOVA Summary Table of GSR Magnitude for Incidental Condition: Orienting Question vs Imperative Stimulus.

SOURCE	DF	SS	MS	F
SUBJECTS	19	15.92		
W1(LEVELS)	2	0.21	0.11	4.118*
EW1B(ERROR)	38	0.98	0.03	
W2(STIMULI)	1	3.17	3.17	33.776**
EW2B(ERROR)	19	1.78	0.09	
W12	2	0.00	0.00	0.103
EW12B(ERROR)	38	0.66	0.02	
W	100	6.80		
TSQ/N= 33.72		N= 120	SST=	22.72

* p<.05   ** p<.01

APPENDIX 4.9

ANOVA Summary Table of GSR Magnitude for Intentional Condition: Orienting Question vs Imperative Stimulus.

SOURCE	DF	SS	MS	F
SUBJECTS	19	23.75		
W1(LEVELS)	2	0.01	0.00	0.288
EW1B(ERROR)	38	0.62	0.02	
W2(STIMULI)	1	2.23	2.23	20.858**
EW2B(ERROR)	19	2.03	0.11	
W12	2	0.01	0.00	0.874
EW12B(ERROR)	38	0.18	0.00	
W	100	5.08		
TSQ/N=	32.08	N= 120	SST=	28.83

* $p<.05$ ** $p<.01$

APPENDIX 4.10

ANOVA Summary Table: Within-Ss Analysis of GSR Frequency to the Orienting Task for Incidental Condition.

SOURCE	DF	SS	MS	F
SUBJECTS	19	2.79		
W1(LEVELS)	2	0.14	0.07	4.446*
EW1B(ERROR)	38	0.60	0.02	
W	40	0.74		
TSQ/N=	31.39	N= 60	SST=	3.53

* p<.05   ** p<.01

APPENDIX 4.11

ANOVA Summary Table: Within-Ss Analysis of GSR Frequency

to the Orienting Task for Intentional Condition.

SOURCE	DF	SS		MS	F
SUBJECTS	19	2.80			
W1(LEVELS)	2	0.02		0.01	0.667
EW1B(ERROR)	38	0.54		0.01	
W	40	0.56			
TSQ/N=	31.10	N=	60	SST=	3.36

* p<.05   ** p<.01

APPENDIX 4.12

ANOVA Summary Table: Within S-s Analysis of GSR Frequency for Incidental Condition: Orienting Task vs Imperative Stimulus.

SOURCE	DF	SS		MS	F
SUBJECTS	19	1.15			
W1(LEVELS)	2	0.00		0.00	0.044
EW1B(ERROR)	38	1.80		0.05	
W2(STIMULI)	1	1.59		1.59	101.754**
EW2B(ERROR)	19	0.30		0.02	
W12	2	0.02		0.01	0.247
EW12B(ERROR)	38	1.19		0.03	
W	100	4.89			
TSQ/N=	84.34	N=	120	SST=	6.04

* $p < .05$ ** $p < .01$

APPENDIX 4.13

ANOVA Summary Table: Within-Ss Analysis of GSR Frequency for Intentional Condition: Orienting Task vs Imperative Stimulus.

SOURCE	DF	SS	MS	F
SUBJECTS	19	1.93		
W1(LEVELS)	2	0.02	0.01	0.610
EW1B(ERROR)	38	0.50	0.01	
W2(STIMULI)	1	1.34	1.34	23.553**
EW2B(ERROR)	19	1.08	0.06	
W12	2	0.02	0.01	1.969
EW12B(ERROR)	38	0.22	0.01	
W	100	3.20		
TSQ/N=	81.84	N= 120	SST=	5.13

* p<.05　　　** p<.01

APPENDIX 4.14

ANOVA Summary Table: Within-Ss Analysis of GSR Latency to the Imperative Stimulus for Incidental Condition.

SOURCE	DF	SS	MS	F
SUBJECTS	19	707.81		
W1(LEVELS)	2	14.00	7.00	2.693
EW1B(ERROR)	38	98.75	2.60	
W	40	112.75		
TSQ/N=	15746.40	N= 60	SST=	820.56

* p<.05   ** p<.01

APPENDIX 4.15

ANOVA Summary Table: Within-Ss Analysis of GSR Latency to Imperative Stimulus for Intentional Condition.

SOURCE	DF	SS	MS	F
SUBJECTS	19	434.76		
W1(LEVELS)	2	3.34	1.67	0.915
EW1B(ERROR)	38	69.30	1.82	
W	40	72.64		
TSQ/N=	12836.36	N= 60	SST=	507.40

* p<.05   ** p<.01